Appendix A: Glossary of Terms

Accretion- an increase of solid materials by natural growth or by gradual external addition. Accretion is the opposite of erosion.

Administrative decision- refers to a final order or determination by the ultimate authority for a state agency, and which may be cited as precedent in an administrative or civil case, under IC 4-21.5.

Administrative Orders and Procedures Act or AOPA- refers to IC 4-21.5.

Administrative review- the process initiated when a person petitions the ultimate authority for an agency to reconsider an agency action, with the ultimate authority or its administrative law judge conducting any resulting hearing *de novo*.

Aquifer- an underground geologic formation that:
1. is consolidated or unconsolidated; and
2. has the ability to receive, store, and transmit water in amounts sufficient for the satisfaction of any beneficial use of water.

Backshore- The zone of the shore or beach lying between the foreshore and the coastline and acted upon by waves only during severe storms, especially when combined with exceptionally high water.

Beach- The zone of sedimentary material that extends landward from the low water line to the place where there is marked change in material or form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach--unless otherwise specified--is the mean low water line. A beach includes foreshore and backshore. The Indiana portion of the Lake Michigan coast which is at or lakeward of the ordinary high watermark (established at 581.5 feet, IGLD (1985)).

Beach nourishment- as used in the rules governing Indiana's navigable waters (codified at 312 IAC 6), is the placement of sand to mitigate beach erosion
1. within the ordinary high watermark of Lake Michigan; or
2. within such proximity to the shoreline of Lake Michigan that wind or water erosion is likely to transport sand into the lake.

Beneficial use of water- a use of water for any useful and productive purpose. The term includes the following uses: domestic; agricultural, including irrigation; industrial; commercial; power generation; energy conversion; public water supply; waste assimilation; navigation; fish and wildlife; and recreational.

Bioaccumulative chemicals- substances that increase in concentration in living organisms, and are very slowly metabolized or excreted, as they breathe contaminated air or water, drink contaminated water, or eat contaminated food. Twenty-two substances have been designated at bioaccumulative chemicals of concern under the Great Lakes Initiative.

Bluff- land that slopes toward a waterbody and rises at least 25 feet above the waterbody at an average slope of 30 percent or greater.

Boat- a watercraft.

Breakwater- a structure, usually detached from the shoreline, protecting a shore area, harbor, anchorage or basin from waves.

Brownfield- an industrial or a commercial parcel of real estate:

1. that:
   (A) is abandoned or inactive; or
   (B) may not be operated at its appropriate use;
2. and on which expansion or redevelopment is complicated because of the actual or perceived presence of a hazardous substance or petroleum released into the surface or subsurface soil or groundwater that poses a risk to human health and the environment.

Budget agency- the Indiana budget agency created under IC 4-12-1-3.

Bulkhead - A structure or partition placed on a bank or bluff to retain or prevent sliding of the land and protect the inland area against damage from wave action. See also seawall.

CERCLA- the federal Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (42 USC 9601, *et seq*.).

Clean Water Act- 33 USC 1251, *et seq*., and regulations adopted under 33 USC 1251, *et seq*.

Coast - The strip of land, of indefinite width (up to several miles), that extends from the shoreline inland to the first major change in terrain features.

Coastal area or region- The term describes the "coastal zone" for Indiana as the term "coastal zone" is used in 16 USC 1453(1).

Coastal area of significance- describes "special management area" as the phrase is used in the regulations adopted under the CZMA.

Coastal hazard- the adverse effects which result from flooding, erosion, accretion, subsidence, reliction, and lake level rise or fall.

Coastal resources of national significance- resources with significant ecological, cultural, historic, and esthetic values.

Coastal waters- the waters within the territorial jurisdiction of the U.S. consisting of the Great Lakes, their connecting waters, harbors, roadsteads, and estuary-type areas such as bays, shallows, and marshes.

Coastal Zone Management Act (CZMA)- 16 USC 1451, *et seq*., and regulations adopted under 16 USC 1451, *et seq*.

Codification- the process of collecting and arranging systematically, by subject, the statutes, regulations, or rules of the federal government or a state government.

Condemnation- the process of taking private property for public use through the power of eminent domain.

Confined feeding- the confined feeding of animals for food, fur, or pleasure in lots, pens, ponds, sheds, or buildings where:

- animals are confined, fed, and maintained for at least forty-five days during any twelve month period; and
- ground cover or vegetation is not sustained over at least fifty percent of the animal confinement area.

The term does not include the following:

- A livestock market:
  - where animals are assembled from at least two sources to be publicly auctioned or privately sold on a commission basis; and
  - that is under state or federal supervision.

- A livestock sale barn or auction market where animals are kept for not more than ten days.

Confined feeding operation-

1. any feeding of:
   - at least three hundred (300) cattle;
   - at least six hundred (600) swine or sheep; and
   - at least thirty thousand (30,000) fowl;
2. any animal feeding operation electing to be subject to IC 13-18-10; or
3. any animal feeding operation that is causing a violation of:
   - water pollution control laws;
   - any rules of the water pollution control board; or
   - IC 13-18-10.

Conservancy district- an entity created under IC 14-33 (or under IC 13-3-3 before its repeal) for any of the following purposes:

1. Flood prevention and control.
2. Improving drainage.
3. Providing for irrigation.
4. Providing water supply, including treatment and distribution, for domestic, industrial, and public use.
5. Providing for the collection, treatment, and disposal of sewage and other liquid wastes.
6. Developing forests, wildlife areas, parks, and recreational facilities if feasible in connection with beneficial water management.
7. Preventing the loss of topsoil from injurious water erosion.
8. Storage of water for augmentation of stream flow.
9. Operation, maintenance, and improvement of:
   - a work of improvement for water based recreational purposes; or
   - other work of improvement that could have been built for any other purpose referenced in the definition.

Conservation easement- a nonpossessory interest in real property by which a person imposes limitations or affirmative obligations, the purposes of which include:

1. retaining or protecting natural, scenic, or open-space values of real property;
2. assuring its availability for agricultural, forest, recreational, or open-space use;
3. protecting natural resources;
4. maintaining or enhancing air or water quality; or

5. preserving the historical, architectural, archeological, or cultural aspects of real property.

Conservation officer- an officer employee of the division of law enforcement of the DNR.

Cumulative effects- the impact which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what person undertakes the other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time. For purposes of determining cumulative effects within a floodway, each of the following elements is considered:

- Adverse effects on the efficiency of, or undue restrictions to the capacity of, the floodway.
- Unreasonable hazards to the safety of life or property.
- Unreasonable detrimental effects upon fish, wildlife, or botanical resources.

Current - A flow of water.

Dam- any artificial barrier, together with appurtenant works, which does or may impound water.

Diffused surface water- water that comes from falling rain or melting snow or ice and that:

1. is diffused over the surface of the ground or that temporarily flows vagrantly on or over the surface of the ground as the natural elevations and depressions of the surface of the earth guide the water; and
2. has no definite banks or channel.

DNR- the Indiana Department of Natural Resources created by IC 14-9-1-1.

Downdrift - The direction of predominant movement of littoral materials.

Dune - A ridge or mound of loose, wind-blown material, usually sand.

Endangered species-

1. an animal, other than an insect, whose prospects for survival or recruitment within Indiana is in immediate jeopardy and is in danger of disappearing from the state. Included are all species classified as endangered by the federal government which occur in Indiana.
2. an insect whose prospects for survival or recruitment within Indiana are in immediate jeopardy, and is in danger of disappearing from the state, where any of the following three conditions occur:
    - A species which may occur in Indiana is classified as endangered by the federal government;
    - A species is biologically dependent on a threatened or endangered plant species;
    - A species is known from fewer than five sites in Indiana.

   An insect is also considered endangered if the insect is listed as extirpated but is later rediscovered in Indiana, whether the population is endemic or believed to be recently adventive. The discovery of any life stage of an extirpated or endangered species is fiduciary evidence that a population exists.

3. a plant known to occur currently on five or fewer sites in Indiana.

Energy facilities- any equipment or facility which is or will be used primarily in the exploration for or the development, production, conversion, storage, transfer, processing, or transportation of an energy resource.

Enforceable policy- law

Environmental impact statement- federal environmental impact statement and state environmental impact statement.

Erosion- the gradual process by which land surfaces are worn away through weathering, transportation, or corrosion. On a beach, the carrying away of beach material by wave action, littoral currents or wind. Erosion is the opposite of accretion.

Exemption- a release from a burden, duty, or obligation. An exemption from a law is strictly construed by placing the burden of providing the exemption upon the person claiming it.

Exotic species- species not native to Indiana

Extirpated species-

1. an animal, other than an insect that has been absent from Indiana as a naturally occurring breeding population for more than 15 years but exists outside Indiana as a wild population.
2. an insect for which any of the following three conditions occur:
   - A species is declared extirpated from Indiana by a specialist for the species, family, or order to which the insect belongs;
   - A species has not been located in Indiana as a naturally occurring breeding population for more than 15 years, but the species exists outside Indiana as a wild population;
   - A species appears on a federal list as being extirpated in Indiana;
3. a plant believed to be originally native to Indiana but without any currently known populations within the state.

Federal consistency- a requirement in the CZMA that federal actions that affect any land or water use or nature resource of the coastal area be consistent with the laws identified in the Indiana program. Federal actions include federal activities (actions by federal agencies, including development projects), federal licenses (actions by any person that require federal permission), and federal financial assistance to state and local government. For federal activities, the standard is "consistent to the maximum extent practicable." For federal licenses and federal financial assistance, the standard is "consistent."

Federal environmental impact statement- a document prepared for all major federal actions having a significant impact on the environment which describes the environmental impact of the action, the negative environmental affects which cannot be avoided if the proposed action is implemented, alternatives to the action, and any irreversible commitments of resources that an action would involve should it be implemented. To determine whether there is a need to prepare an environmental impact statement, an environmental assessment is often prepared first.

Fetch - The unobstructed distance over water in which waves are generated by wind of relatively constant direction and speed.

Flood or Flood water- the water of a river, stream, or lake in Indiana, or upon or adjoining a boundary line of Indiana, that is above the bank or outside the channel and banks of the river, stream, or lake.

Flood hazard area- those flood plains or parts of flood plains that have not been adequately protected from flood water by means of dikes, levees, reservoirs, or other works approved by the DNR.

Flood plain- the area adjoining a river or stream that has or may be covered by flood water.

Floodway- the channel of a river or stream, and the parts of the flood plain adjoining the channel, that are reasonable required to efficiently carry and discharge the flood water during a regulatory flood.

Foreshore - The part of the shore lying between the crest of the seaward berm (or upper limit of wave wash) and the water's edge at low water. The foreshore is ordinarily traversed by the runup and return of the waves.

Fragmentation- the process through which large continuous areas of habitat are reduced in area and separated into discrete parcels. The discrete parcels become isolated from other areas of similar habitat by roads, railroads, canals, power lines, or other means of landscape modification.

General permit- a permit for a regulated activity, the terms and conditions of which are defined by rule or regulation, and to which a person may elect to adhere instead of completing a formal application process for the activity.

Grant- a financial assistance instrument and refers also to a cooperative agreement.

Great Lakes Basin Compact- an agreement among the eight Great Lakes States that recognizes the need for cooperative action in the Great Lakes Basin. The Compact was ratified through the collective legislative action of the eight Great Lakes States and later approved by Congress. The Compact establishes the Great Lakes Commission and identifies the geographic boundary where the Commission’s powers and functions are exercised. The purposes of this Compact are, through means of joint or cooperative action: (1) To promote the orderly, integrated, and comprehensive development, use, and conservation of the water resources of the Great Lakes Basin. (2) To plan for the welfare and development of the water resources of the Basin as a whole as well as for those portions of the Basin which may have problems of special concern. (3) To make it possible for the states of the Basin and their people to derive the maximum benefit from utilization of public works, in the form of navigational aids or otherwise, which may exist or which may be constructed from time to time. (4) To advise in securing and maintaining a proper balance among industrial, commercial, agricultural, water supply, residential, recreational, and other legitimate uses of the water resources of the Basin. (5) To establish and maintain an intergovernmental agency the end that the purposes of this compact may be accomplished more effectively.

Groin- a fingerlike structure built perpendicular to the shoreline, usually with other groins, to trap littoral drift or retard erosion of the shore.

Ground water- all water occuring beneath the surface of the ground regardless of location and form.

Historic site- a site that is important to the general, archaeological, agricultural, economic, social, political, architectural, industrial or cultural history of Indiana. The term includes adjacent property that is necessary for the preservation or restoration of the site.

Indiana Administrative Code (IAC)- the codification of rules adopted by state agencies within the Indiana Administrative Code.

Indiana Code (IC)- the codification of legislative enactments by the Indiana General Assembly contained within the Indiana Code.

Includes- “includes but is not limited to.”

Indiana Environmental Policy Act- refers to IC 13-12-3 and IC 13-12-4.

Jetty- on an open coast, a structure extending into a body of water, and designed to prevent build-up of littoral materials in a channel. Jetties are built at the mouth of harbors or other navigable waterways.

Lake Michigan Coastal Program document- a comprehensive statement in words, maps, illustrations, or other media of communication, prepared and adopted by Indiana under the CZMA, which sets forth laws, objectives, policies, and standards to guide public and private uses of lands and waters in the coastal area.

Law- a constitutional provision, judicial decision, administrative decision, statute, regulation, rule, or other legally binding document by which Indiana exerts control over private and public land and water uses and natural resources in the coastal area. A law describes the term "enforceable policy" as that term is used in 16 USC 1453(6a).

Littoral- the shore of a lake, reservoir, or other standing body of water.

Littoral drift- the movement of sediments, caused by wave action, along the coastline. On the southern shoreline of Lake Michigan, from the Michigan state line to Gary, littoral drift carries sediments from the east toward the west. From the Illinois state line to Gary, littoral drift carries sediments from the west toward the east.

Littoral transport - The movement of littoral drift along the shoreline by waves and currents. Includes movement parallel (longshore transport) and perpindicular (on-offshore transport) to the shore.

Local government- a political subdivision of, or a special entity created by, Indiana which (in whole or part) is located in, or has authority over, the coastal area and which either:

1. has authority to levy taxes or to establish and collect user fees; or
2. provides a public facility or public service which is financed in whole or part by taxes or user fees.

The term includes a county, city, town, school district, fire district, transportation authority, port authority, conservancy district, and any other special purpose district or authority.

Local zoning ordinance, decision, or other action- any local government land or water use action which regulates or restricts the construction, alteration of use of land, water or structures. These actions include zoning ordinances, master plans, and official maps.

Longshore - Parallel to and near the shoreline.

Motorboat- a watercraft propelled by an internal combustion, steam, or electrical inboard or outboard motor or engine or by another mechanical means. The term includes a sailboat that is equipped with a motor or an engine when the motor or engine is in operation, whether or not the sails are hoisted. The term also includes a personal watercraft.

Management program decision- any major, discretionary policy decisions on the part of a management agency, such as the determination of permissible land and water uses, the designation of areas of particular concern or areas for preservation or restoration, or the decision to acquire property for public uses. Regulatory actions which are taken pursuant to these major decisions are not subject to the State-local consultation mechanisms. A State management program decision is in conflict with a local zoning ordinance if the decision is contradictory to that ordinance.

Municipality- a city or town.

National Environmental Policy Act (NEPA)- 42 USC 4321, *et. seq.*

Natural Resources Commission (NRC)- established at IC 14-10-1-1, the NRC is a board that addresses issues pertaining to the Department of Natural Resources. Adjudication, rule adoption, and many other daily functions of the commission are performed through its Division of Hearings.

Natural resource damages- damages to land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other resources compensible under CERCLA (42 USC 960, *et. seq*.), the CWA (33 USC 125, *et. seq*.), or the Oil Pollution Act of 1990 (33 USC 2701, *et. seq*.).

Natural resource trustee- a person designated to assist in the administration of trust money received by the State of Indiana as compensation for natural resource damages. Included as trustees for Indiana are representatives from the U.S. Fish and Wildlife Service for Region 3, Indiana Department of Environmental Management, and the Indiana Department of Natural Resources.

Nature preserve- an area in which an estate, an interest, or a right has been formally dedicated under IC 14-31-1-11.

Navigable waters- a river, stream, or lake which was capable of commerce according to the general rules of waterway transportation in 1816. However, for the purposes of the Clean Water Act and IC 13-24-3, “navigable waters” has the meaning set forth at 33 USC 1362(7).

Nonpoint source pollution- water pollution that results from a variety of human activities such as soil erosion, agriculture, urban runoff, development, logging, resource extraction, and deposition from air pollution.

Nonrule policy document- an agency statement that interprets, supplements, or implements a statute and which has not been adopted as a rule (and is not intended by the agency to have the effect of law), but that may be used in conducting the agency’s external affairs. A nonenforceable policy under the CZMA is a nonrule policy document.

Nourishment - The process of replenishing a beach. It may be brought about naturally, by accretion due to the longshore transport, or artificially, by the deposition of dredged materials.

Offshore - The direction away from the shore, toward a large body of water. Onshore - The landward direction, away from the water.

Ordinance- a measure of local governance adopted by a county, municipality, or township under IC 36-1. The expressed policy of Indiana is to grant these local units all the powers needed to adopt ordinances for the effective operation of government as to local affairs. Excluded from these powers is the power to regulate activity that is regulated by a state agency, except as is expressly granted by statute.

Ordinary high watermark- the line on the shore of a river, stream, or lake established by the fluctuations of water and indicated by physical characteristics. Examples of these physical characteristics include the following:
- A clear and natural line impressed on the bank;
- Shelving;
- Changes in the character of the soil;
- The destruction of terrestrial vegetation;
- The presence of litter or debris.

For Lake Michigan, the ordinary high watermark defines the extent of the beach.

Overtopping - The passing of water over the top of a natural or man-made structure as a result of wave runup or surge.

Person- an individual, corporation, partnership, association, or other entity organized or existing under Indiana law. The term also includes the state, a state agency, and a local government entity.

Permit- means a license, franchise, certification, approval, registration, charter, or similar form of authorization that may be issued to a person by a state agency under Indiana law.

Personal watercraft- a watercraft: whose primary source of motive power is an inboard motor powering a water jet pump; and that is designed to be operated by a person who sites, stands, or kneels on the surface of the watercraft rather than sitting or standing inside the watercraft.

Pesticide- a substance or a combination of substances commercially produced for use as:
an insecticide; a rodenticide; or a nematodicide.

Pile - A long, heavy timber or section of concrete or metal that is driven or jetted into the earth or bottom of a water body to serve as a structural support or protection.

Pollution prevention- source reduction and other practices that reduce or eliminate the creation of pollutants through (1) increased efficiency in the use of raw materials, energy, water, or other sources; or (2) protection of natural resources by conservation.

Potable water- water that at the point of use is acceptable for human consumption under drinking water quality standards adopted by the water pollution control board.

Public freshwater lake- a lake that has been used by the public with the acquiescence of a riparian owner. The term does not include Lake Michigan, Wolf Lake in Hammond, or George Lake in Hammond.

Public trust doctrine- the obligation of the State to hold in trust sovereign resources, including the use of navigable waters, for the benefit of the general public, free from undue private interruption and encroachment.

Rare species-
1. an animal, other than an insect, where some problems of limited abundance or distribution in Indiana are known or suspected and should be closely monitored.

2. An insect where problems of limited abundance or distribution in Indiana are known or reasonably suspected including the following:
   - A species that is known to be rare in Michigan, Ohio, Illinois, or Kentucky;
   - A species that is biologically dependent upon a rare plant species;
3. A plant known to occur currently on eleven to 20 sites in Indiana.

A rare species of insect references an established population and does not include accidentals, adventive nonregulated species, or other species regulated under IC 14-24 and 312 IAC 18.

Recycling- a process by which materials that would otherwise become solid waste are: collected; separated or processed; and converted into materials or products for reuse or sale.

Regulation- a measure intended to have the force and effect of law and adopted by a federal agency under 5 USC 551 through 559.

Regulatory flood- a flood which has a peak discharge which can be expected to be equaled or exceeded on the average of once in a 100-year period, as calculated by a method and procedure approved by the Natural Resources Commission.

Reliction- the exposure of the bottom of a lake or stream as dry land due to the slow retreat of water.

Revetment- any hardened shoreline to protect softer land behind it. Revetments may be constructed of steel sheet piling, stone, concrete, wood or a combination of these.

Riparian owner- the owner of land, or the owner of an interest in land sufficient to establish the same legal standing as the owner of land, bound of a river, stream, or lake. The term includes a littoral owner.

Rubble- rough irregular fragments of broken rock.

Runup - The rush of water up a beach or structure, associated with the breaking of a wave. The amount of runup is measured according to the vertical height above still water level that the rush of water reaches.

Rule- a measure intended to have the force and effect of law and adopted by a state agency under IC 4-22-2; a state agency statement, designed to have the effect of law that implements, interprets, or prescribes either a law or policy or the organization, procedure, or practice requirements of the agency.

SARA- Title III of the Superfund Amendments and Reauthorization Act of 1986 (P.L. 99-499).

Scour - Removal of underwater material by waves and currents, especially at the base or toe of a shoreline structure

Seawall - A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action. See also bulkhead.

Sheet pile - A pile with a generally slender, flat coss-section that is driven into the ground or bottom of a water body and meshed or interlocked with like members to form a wall or bulkhead.

Shore - The narrow strip of land in immediate contact with the water, including the zone between high and low water lines. See also backshore and foreshore.

Significant ground water withdrawal facility- the ground water withdrawal facility of a person that, in the aggregate from all sources and by all methods, has the capability of withdrawing at least one hundred thousand gallons of ground water in one day.

Significant water withdrawal facility- a water pumping installation or other equipment of a person that, in the aggregate from all sources and by all methods, has the capability of withdrawing at least one hundred thousand gallons of water in one day.

Source reduction- a practice which (1) reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream, or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and, (2) reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants.

Special area management plan- a comprehensive plan providing for natural resource protection and reasonable coastal-dependent economic growth containing a detailed and comprehensive statement of policies, standards and criteria to guide public and private uses of lands and waters, and mechanisms for timely implementation in specific geographic areas within the coastal area.

State environmental impact statement- a detailed statement by the official responsible for a major state action which considers the environmental impact of the proposed action, any adverse environmental impact which cannot be avoided if the proposal is implemented, alternatives to the proposed action, the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources which would be involved if the proposed action is implemented. To determine whether there is a need to prepare an environmental impact statement, an environmental assessment is often prepared first.

Submerged Bulkhead: an underwater structure designed to retain sand or landfill to the shore side. The lake bottom on the lake side is deeper. Submerged bulkheads are used to create plateaus or perched beaches.

Subsidence- the lowering or collapse of the land surface caused by natural and human-induced activities.

Superfund- CERCLA program.

Surface water- all water occurring on the surface of the ground. The term includes water in a stream; natural and artificial lakes; ponds; swales; marshes; and diffused surface water.

Swale- a slight depression, sometimes swampy, in the midst of generally level land.

Tank system- underground storage tank, connected underground piping, underground ancillary equipment, and containment system, if any.

Threatened species-

1. an animal, other than an insect, which is likely to become an endangered species within the foreseeable future. Included are all species classified as threatened by the federal government which occur in Indiana.

2. an insect which is likely to become an endangered species within the foreseeable future, where any of the following conditions occur:
   - species which occurs in Indiana is classified as threatened by the federal government.
   - species is biologically dependent upon a rare or threatened plant species.
   - species is known from six to ten sites in Indiana.
3. a plant know to occur currently on six to ten sites in Indiana.

The discovery of a single life stage in *situ* is fiduciary evidence that a population exists. A threatened species does not include accidentals, adventive nonregulated species, nor any species subject to IC 14-24 and 312 IAC 18 (including a species used for biological control).

Underground storage tank- a tank or combination of tanks, including underground pipes connected to the tank or combination of tanks, that is used to contain an accumulation of petroleum or another substance regulated by IDEM under IC 13-23, the volume of which (including the volume of the underground connecting pipes) is at least 10% beneath the surface of the ground.

Updrift - The direction opposite that of the predominant movement of littoral materials.

Ultimate authority- an individual or panel of individuals in whom the final authority of an agency is vested. For IDEM, the "ultimate authority" is the Office of Environmental Adjudication. For DNR, the "ultimate authority" is the NRC or its Division of Hearings. For ISDH, the "ultimate authority" is the Executive Board or an appeals panel if designated by statute.

Watercraft- any instrumentality or device in or by means of which a person may be transported upon the public waters of Indiana. The term includes a motorboat, sailboat, rowboat, skiff, dinghy, or canoe of any length or size and whether or not used to carry passengers for hire.

Water use- a use, activity, or project conducted in or on waters within the coastal area.

Wave height - The vertical distance between a wave crest and the preceding trough.

Wave length - The horizontal distance between similar points on two successive waves (for example, crest to crest or trough to trough), measured in the direction of wave travel.

Wild animal- an animal whose species usually lives in the wild or is not domesticated.

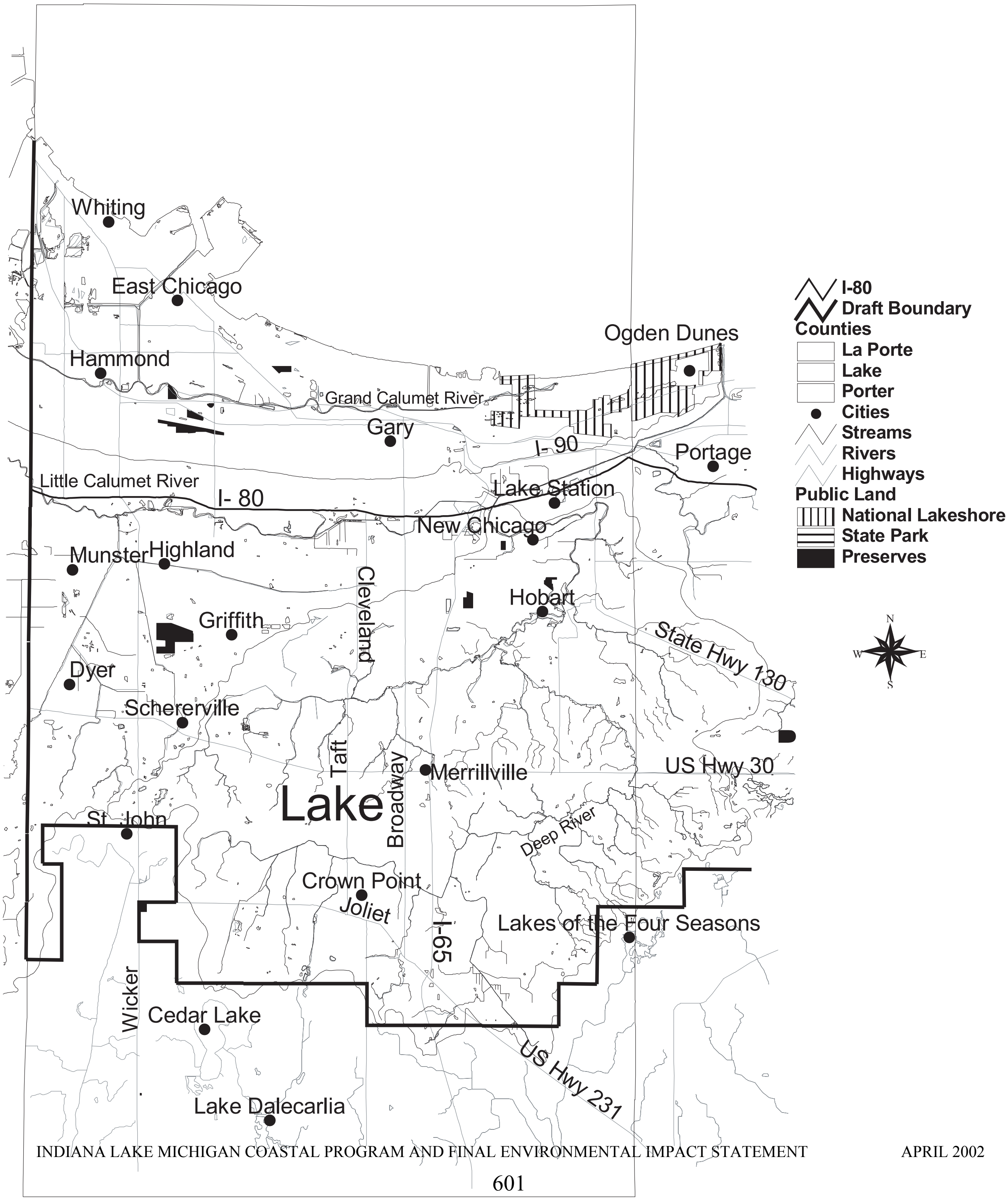
Appendix B: List of Acronyms

ACOE	U.S. Army Corps of Engineers
AOC	Area of Concern
AOPA	Administrative Orders and Procedures Act
APC	Area of Particular Concern
BMP	Best Management Practices
CAA	Clean Air Act
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, & Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
CZARA	Coastal Zone Act Reauthorization Amendments of 1990
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DEIS	Draft Environmental Impact Statement
DNR	Indiana Department of Natural Resources
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHA	Federal Highway Administration
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information System
GLWQA	Great Lakes Water Quality Agreement
IAC	Indiana Administrative Code
IC	Indiana Code
IDEM	Indiana Department of Environmental Management
INDOT	Indiana Department of Transportation
IEPA	the Indiana Environmental Policy Act, IC 13-12-3 and IC 13-12-4
IREDB	Indiana Recycling and Energy Development Board
ISDH	Indiana State Department of Health
IURC	Indiana Utility Regulatory Commission
LMCP	Indiana Lake Michigan Coastal Program
ISTEA	Intermodal Surface Transportation and Efficiency Act
IGLD	International Great Lakes Datum
IJC	International Joint Commission
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NIRPC	Northwestern Indiana Regional Planning Commission
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System

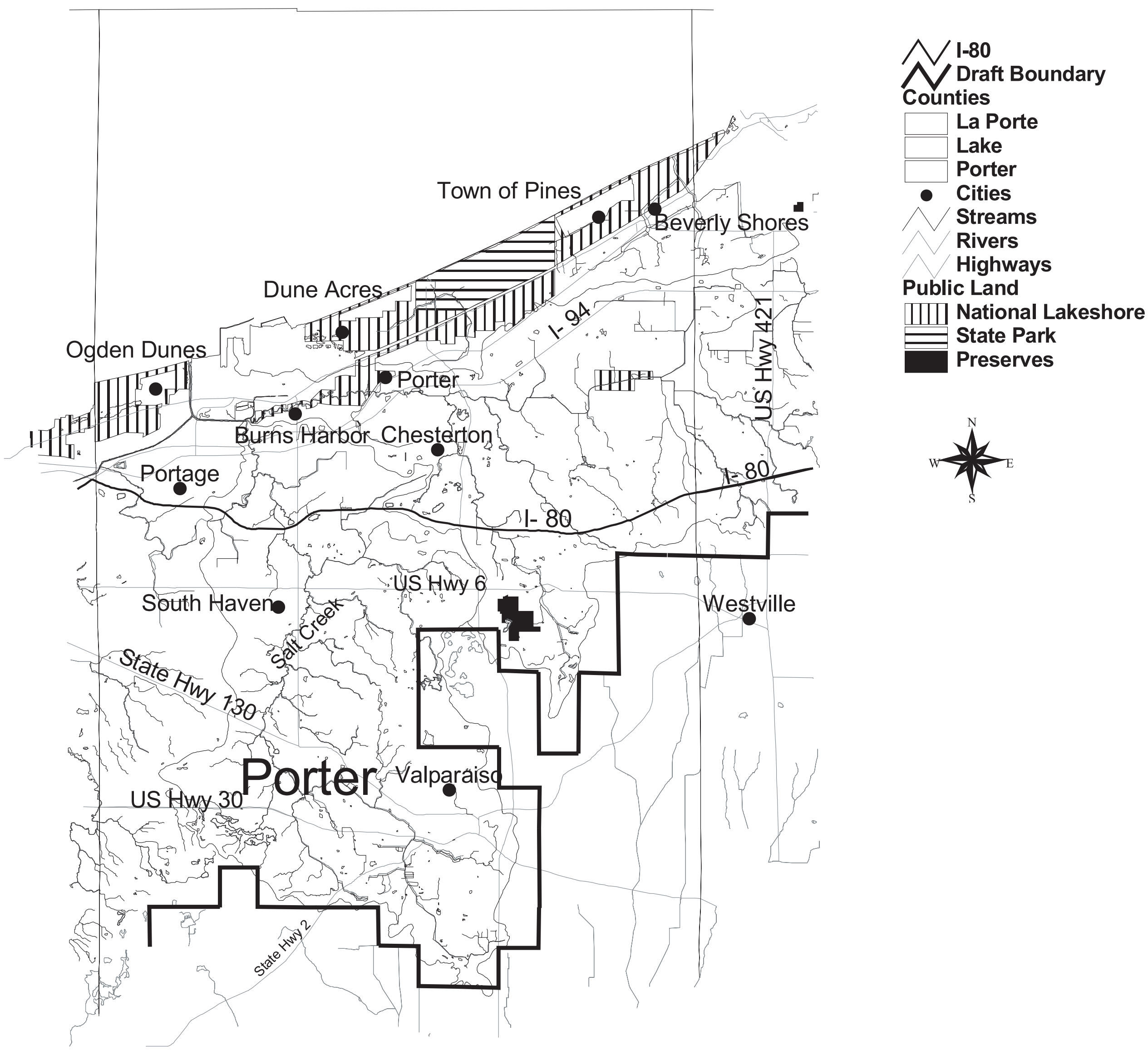
NPS	Nonpoint source pollution
NRCS	Natural Resources Conservation Service
OCRM	Office of Ocean and Coastal Resource Management
OHW	Ordinary high water mark
P/DEIS	Indiana Lake Michigan Coastal Program and Draft Environmental Impact Statement
P/FEIS	Indiana Lake Michigan Coastal Program and Final Environmental Impact Statement
RAP	Remedial Action Plan
RCRA	Resources Conservation and Recovery Act
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SDWA	Safe Drinking Water Act
SEMA	State Emergency Management Agency
SHPO	State Historic Preservation Officer
SWCD	Soil and Water Conservation District
USC	United States Code
USDA	U.S. Department of Agriculture
UST	Underground storage tank
WHPA	Well Head Protection Act

Appendix C: County Maps and Detailed Written Description of the Coastal Program Area

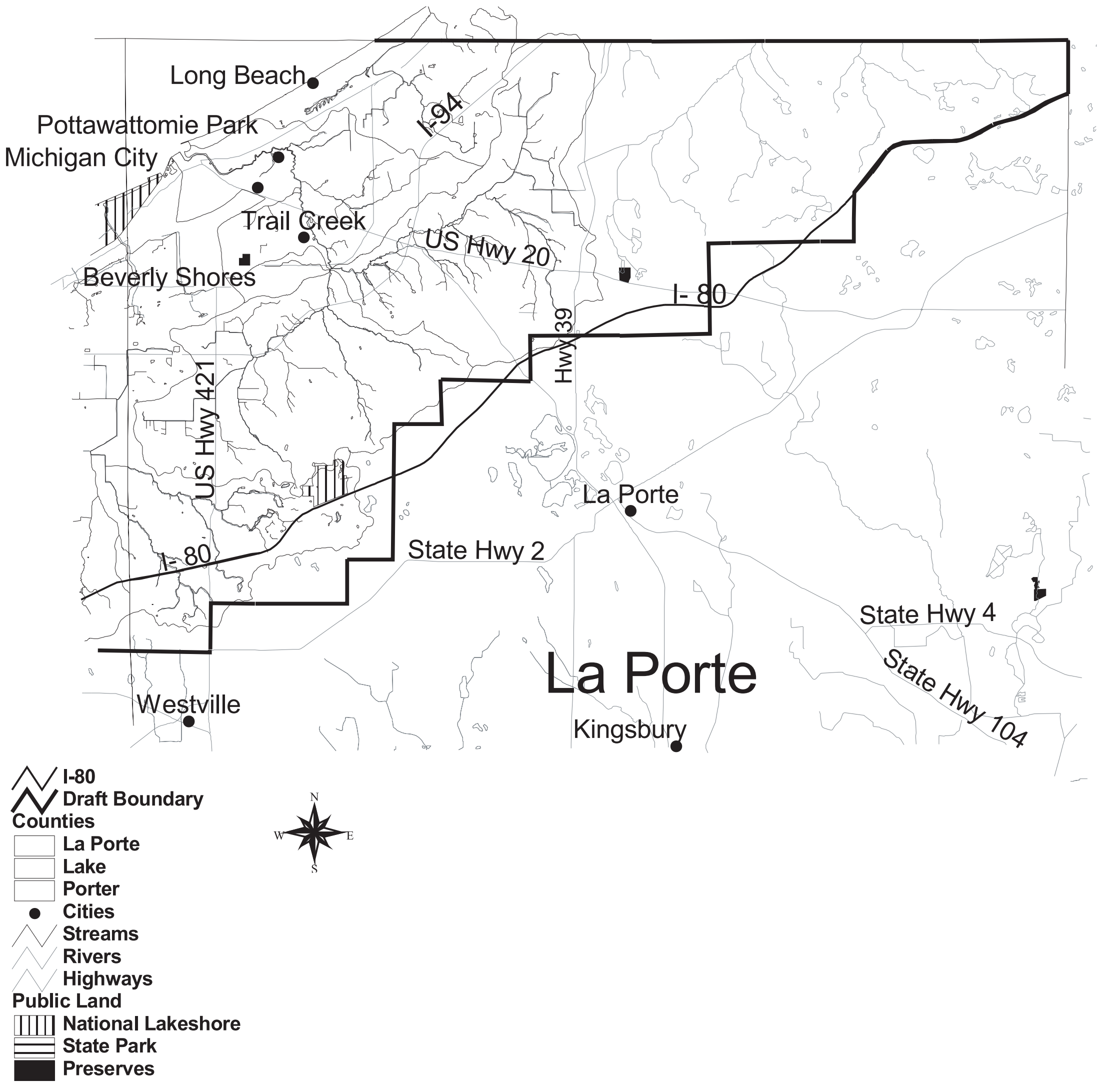
Lake Michigan Coastal Program Area: Lake County



Lake Michigan Coastal Program Area: Porter County



Lake Michigan Coastal Program Area:
La Porte County



Detailed written description of the Coastal Program Area

Although the written description is cumbersome, the boundary can be easily determined using Quadrangle maps. Township, Range, and Section will be abbreviated as follows: Township 34 North, Range 2 West, Section 10 will be written as Section 10, T34N, R2W. Road names from the quadrangle maps will be used where needed. Figure 3.3 shows the Coastal Program's inland boundary.

Lake County

On the Dyer Quadrangle, the inland boundary proceeds east from the State line along 125th Avenue to the east line of Section 13, T34N, R10W (Calumet Avenue). The boundary proceeds north along Calumet Avenue to the south line of Section 31 T35N, R9W. Then it proceeds west to Sheffield Avenue where the boundary proceeds north to the south line of Section 25 T35N R10W. The boundary then proceeds east along the south line of Section 25 T35N R10W and Section 30 T35N R9W onto the St. John Quadrangle. Then it continues east along the south line of Sections 30, 29, and 28 T35N R9W to the west line of Section 34 T35N 9W. Then it proceeds south along the west line of said Section 34 and the west line of Section 3 T34N R9W to the south line of Section 4 T34N R9W (109th Avenue). Then it proceeds west along 109th Avenue to the west line of Section 9 T34N R9W. Then the boundary proceeds south to the south line of Section 9 T35N R9W (117th Avenue) where it proceeds east to the west line of Section 10 T35N R9W (Parrish Avenue). The boundary then proceeds south to the south line of Section 15 T34 N R9W. There the boundary proceeds east on the south line of Sections 15, 14, 13 T35N R9W and Section 18 T35N R8W to the Crown Point Quadrangle. Then the boundary continues east to the east line of Section 20 T34N R8W. It then proceeds south along the east line of said Section 20 to the bottom of the Crown Point quadrangle. Then the boundary continues east along the bottom of the quadrangle (from 87 22'30" to 87 15' NAD27) to the east line of Section 30 T34N R7W. The boundary then proceeds north along the east line of said Section 30 and Section 19 T34N R7W to the south line of Section 17 T34N R7W then east along the south line of said Section 17 onto the Palmer Quadrangle. On the Palmer Quadrangle, the inland boundary continues east along the south line of Section 17, T34N, R7W to the east line of the same section. Then the boundary proceeds north along the east line of Sections 17 and 8 T34N R7W to the south line of Section 4, T34N R7W (109th Avenue) and then east along the south line of Sections 4 to the county line.

Porter County

The inland boundary continues from the county line east along the south line of Section 3, T34N, R7W to the east line of the same section. Then north along the east line of Section 3, T34N, R7W to the south line of Section 35 T35N, R7W (Division Road). The boundary then proceeds east along the south line of Sections 35 and 36 T35N R7W to the east line of Section 36 T35N, R7W, then north to the south line of Section 30 T35N R6W (100 North Road). The boundary then proceeds east to the west line of Section 32 T35N R6W where it proceeds south to the south line of the same section (Division Road). The boundary then proceeds east on to the Valparaiso Quadrangle along the south line of said Section 32. It continues east along the south line of Sections 33 and 34 T35N R6W to the west line of Section 2 T34N R6W (100W Road). The boundary proceeds south to the south line of the said Section 2 and east along its south line to the west line of Section 12 T34N R6W. Then it proceeds south to the south line of Section 12 T34N R6W and then east along the south line of Sections 12 and 7 T35N R5W to the east line of said Section 7. The boundary then proceeds north to the south line of the Section 5 T35N R5W and east to the east line of said Section 5. Then north along the east line of said Section 5 and Sections 32 and 29 T35N R5W then west along the north line of said Section 20 to the south lone of Section 18 T35N R5W where it proceeds north along said Section 18 to the section’s north line. The boundary then proceeds west along the north lone of Sections 18 and 13 T35N R5W to the east line of Section 11 T35N R6W. The boundary then proceeds north along the east line of Sections 11, 2, and 35 T35N R6W (Campbell Street) to the south line of Section 25 T36N T6W. The boundary then proceeds east along the south line of said Section 25 and Section 30 T36N R5W (700 North) to the east line of Section 31 T36N R5W. The boundary then proceeds south along the east line of said Section 31 to the south line of Section 32 T36N T5W and then east to the east line of Section 5 T35N R 5W. The inland boundary then proceeds south along the east line of Sections 5 and 8 T35N R5W to the south line of said Section 8. Then the boundary proceeds along the north line of Section 16 T35N R5W to the east line of said Section 9 then north to the south line of Section 34 T36N R5W on the Westville Quadrangle. The boundary then proceeds east along the section's south line to its east line (500 East Road). Thence north along the east line of Sections 34, 27, and 22 T36N R5W. The boundary then continues east along the south line of Sections 14 and 13 T36N R5W to the county line.

LaPorte County

From the county line on the Westville Quadrangle, the boundary proceeds east along the south line of Sections 18 and 17 T36N R4W to the east line of said Section 17 where it proceeds north to the south line of Section 9 T36N R4W. The boundary then proceeds east along the south line of said Section 9 into the LaPorte West Quadrangle. On the LaPorte West Quadrangle, the boundary proceeds east on the south line of Sections 10 and 11 T36N R4W to the east line of said Section 11 (700 West Road). Then it proceeds north to the south line of Section 1 T36N R4W thence east along the south line of said Section 1. Then it proceeds north along the east line of Section 1 T36N R4W and Sections 36 and 25 T37N R4W into the Michigan City East Quadrangle. The boundary continues north along the east line of said Section 25 then east along the south line of Section 19 T37N R3W. The boundary then proceeds north along the east line of said Section 19 thence east along the south line of Sections 17 and 16 T37N R3W. It continues north along the east line of said Section 16 then east along the south line of Section 10 onto the Springville Quadrangle. The boundary continues east along the south line of Sections 10, 11, and 12 T37N R3W and Section 7 T37N R2W thence north along the east line of Section 7 and 6 T37N R2W. Then the boundary proceeds east along Sections 32, 33, 34 T37N R2W into the New Carlisle Quadrangle. It continues north along the east line of said Section 34 then north-easterly along Highway 80/90 (East-West) to the county line. Then the boundary proceeds north along the county line to the Indiana-Michigan State line.

Appendix D: Memoranda of Understanding Between State Agencies

MEMORANDUM OF UNDERSTANDING REGARDING WATERWAY PERMITTING PROCESSES

This memorandum of understanding is entered between the Indiana Department of Environmental Management ("IDEM") and the Indiana Department of Natural Resources ("DNR") in order to embody and advance efforts to provide improved public service through more effective, coordinated permitting processes. The memorandum is prepared in direct response to resolutions by the Lake Michigan Marina Development Commission and by the Blue Ribbon Advisory Panel for Indiana's Lake Michigan Shoreline relative to permit coordination and streamlining, but it is also prepared with an understanding efficient government serves all citizens. The memorandum acknowledges current efforts within IDEM and the DNR to advance permit coordination and streamlining and is intended to support not conflict with those efforts.

Additionally, the memorandum acknowledges the critical roles of the Water Pollution Control Board ("WPCB") and the Natural Resources Commission ("NRC") in formulating policy relative to waterway regulation. Although the signatories to this memorandum are IDEM and DNR, advice and participation by the WPCB and NRC will be actively sought in order to most effectively implement its purposes. In addition, advice will be sought from the Lt. Governor's office and from other interested state agencies as the work process moves forward.

Accordingly, a memorandum of understanding is entered between IDEM and DNR by which:

(1) IDEM and DNR agree to work toward better coordination and cooperation with each other.

(2) A technical workgroup will be established to begin June 1, 1998 from IDEM and DNR to establish guidelines for early coordination of the permit process for projects directed to activities within:

A. Lake Michigan and its navigable tributaries.

B. Waterways permitting, generally, in Indiana where it is deemed more productive and more responsive to the two agencies and the applicant.

The technical workgroup will include three representatives from IDEM and three representatives from DNR. In each instance, two of the members will have a direct role in permitting functions. The third member will bring expertise from nonregulatory programs or as agency administrators. Participation of a representative will also be sought from the Lake Michigan Marina Development Commission and from the Blue Ribbon Advisory Panel. Finally, one advisor will be invited in Northwest Indiana from the regulated community and from the environmental community.

(3) The technical workgroup will identify particular strategies to do the following:

A. Determine whether early coordination might be accomplished for a project to include the applicant and IDEM, DNR, and the Army Corps of Engineers (and, as appropriate, the U.S. Fish and Wildlife Service, the Environmental Protection Agency, and the U.S. Coast Guard).

B. Where not already available, establish a process for the applicant to request early permit coordination and negotiation to resolve any disagreements.
C. Establish a measure of success of the joint permitting process,
and whether the development of the joint permit application among IDEM, DNR, and the Army Corps is feasible.
D. Determine whether other methodologies, supportive of streamlining
and protective of the environment, should also be pursued.
E. Pursue the creation of a Permit Handbook of all the permitting
guidelines of IDEM, DNR, and the Army Corps and the Point of Contact for the various permits of each agency.

(4) The technical workgroup will report publicly upon its progress relative to these efforts by December 31, 1998.

(5) IDEM and DNR will jointly publish a permit handbook or brochure to assist local communities in Indiana.

(6) Coordination and cooperation of IDEM and DNR will become effective immediately on all projects where it is deemed appropriate by the applicant or one of the agencies.

APPROVED:

John M. Hamilton, Commissioner	Larry D. Macklin, Director
Indiana Department of Environmental Management	Indiana Department of Natural Resources
Dated: 5/12/98	Dated:

Memorandum of Understanding
Concerning the Interagency Shared Neutrals Program
For Mediation

This Memorandum of Understanding (MOU) establishes the Interagency Shared Neutrals Program among the: Department of Natural Resources (DNR), Indiana Department of Environmental Management (IDEM), Natural Resources Commission (NRC), Office of Environmental Adjudication (OEA), and State Emergency Management Agency (SEMA).

State agencies may engage in mediation. Mediation is defined as:
"a process in which a neutral third person, called a mediator, acts to encourage and to assist in the resolution of a dispute between two (2) or more parties....The objective is to help the disputing parties reach a mutually acceptable agreement between or among themselves on all or any part of the issues in dispute. Decision making power rests with the parties, not the mediator. The mediator assists the parties in identifying issues, fostering joint problem-solving, exploring settlement alternatives, and in other ways consistent with these activities." (Indiana Rules for Alternative Dispute Resolution, Rule 1.3)

Benefits of a Shared Neutrals Program
A Shared Neutrals Program can provide the basic structure to encourage mediation as a method of alternative dispute resolution. In Indiana, the Shared Neutrals program allows state agencies to share the expertise of trained mediators among agencies. Under the Shared Neutrals Program, each agency is able to request and use mediators from other participating agencies; additionally, each agency makes its mediators available to other agencies. Through this interagency agreement state agencies may take advantage of external expertise and resources, on a reciprocal basis, without additional expense.

The Interagency Shared Neutrals Program has many benefits, including:

- Mediation empowers citizens and agency employees by enhancing their understanding of the dispute while increasing their ability to influence the outcome;

- Mediation provides additional opportunities for citizens and agency employees to interact, diffuse conflict, and build more productive working relationships;

- Mediation becomes more readily accessible for agencies and private parties that cannot afford to hire private mediators;

- The perception of mediator impartiality is enhanced when a mediator comes from an agency that is neither a party nor the ultimate authority for a particular dispute;

- Parties are more likely to agree to mediation where they are assured of participation by a mediator who is (and gives the appearance of being) neutral, and where access to a mediator's services is without additional cost to them;

- Opportunities for agency personnel to use and refine their mediation and negotiation training and skills are increased.

Appropriateness of Cases for Mediation
This MOU applies to any proceeding that an ultimate authority has determined under IC 4-21.5-3.5-2 to be appropriate for mediation. In addition, this MOU applies to any matter that is exempt from IC 4-21.5 but where the agency elects to use mediation under IC 4-21.5-3.5-1. Each neutral must qualify as a mediator under IC 4-21.5-3.5-8.

Administration
Agencies will contact Steve Lucas of NRC to request a neutral under this MOU. The program will operate during the trial period without a highly structured and administratively intensive component.

Choice of Mediator
Mediators shall be chosen based on agreement by the mediating parties. In the absence of a specific request for or agreement upon a certain mediator, the administrative law judge assigned to the proceeding will determine the mediator, in accordance with IC 4-21.5-3.5-6.

Agency/Neutral Participation
Participation in this MOU does not require a neutral or an agency to participate in a particular mediation. A neutral or an agency that declines to participate is, however, encouraged but not required to communicate the reason for declining to a representative of the Indiana Conflict Resolution Institute (ICRI) for general tabulation in consultation. ICRI, based at the Indiana University School of Public and Environmental Affairs (SPEA) was established in 1997, and is dedicated to the understanding and expansion of conflict resolution in public and private arenas. ICRI will maintain confidential records regarding reasons for non-participation in the shared neutrals program.

Costs and Expenses
Participation in a particular mediation will be at no additional cost to the mediating agency. Although the services of the mediator are made available under this agreement at no cost to the requesting agency, any travel expenses of the mediator will be covered by the requesting agency. The mediating agency shall incur no additional external costs.

Mediation Agreement
A *Mediation Agreement* will be available for consideration and possible use by the neutral and the mediating parties. This agreement provides a general framework and reiterates the impartiality of the neutral and the confidentiality of the mediation session.

Trial Period
Individuals have expressed their desire initially not to require a strict monitoring and repayment system. For this reason, the shared neutrals program will be run on a trial basis through April 2000 and may be extended by mutual agreement of the parties.

Analysis
ICRI will conduct an evaluation of the program.

- Neutrals will complete a brief *Mediation Tracking Form* with their hours, the number of parties, whether there was settlement, and other non-confidential information and comments for general tabulation by ICRI.
- Mediating parties will be requested to complete an *Exit Survey* to provide constructive feedback for the mediator and the shared neutrals program. The survey will not seek the disclosure of information that, if disclosed, would compromise the integrity of any confidential matter shared during the mediation. The completed survey will be returned to ICRI for tabulation and sharing with the mediator.
- As soon as practicable after April 2000, ICRI will generate a report and provide feedback to the participants in the MOU. The report will include an analysis of the distribution of the mediations by each agency providing and receiving mediation services and an analysis of participant perceptions of the program as reflecting in the exit surveys. Additionally, the report will examine whether there is a need for increased structure in the program.

Signature of this MOU represents an agreement among the participating agencies to engage in the Interagency Shared Neutrals Program as described above.

Joyce Martin   Dec. 9, 1999

Joyce Martin,
Executive Assistant for the Environment
Office of the Governor

Lori T. Kaplan   12-14-99

Lori Kaplan,
Commissioner,
Indiana Department of Environmental Management

_____________________________ 1/4/00

Larry D. Macklin,
Director,
Indiana Department of Natural Resources

_____________________________ January 4, 2000

Steve Lucas,
Administrative Law Judge,
Natural Resources Commission

_____________________________ January 4, 2000

Wayne Penrod Chief
Administrative Law Judge,
Office of Environmental Adjudication

_____________________________ January 6, 2000

Patrick R. Ralston,
Executive Director,
State Emergency Management Agency

Appendix E: List of Federal Agencies Receiving the Lake Michigan Coastal Program Document and Draft Environmental Impact Statement

Letter Sent to Federal Agencies

Division of Water
402 W. Washington St. Rm W2264
Indianapolis, Indiana 46204-4579
PH: (317) 232-4160
FAX: (317) 233-4579

September 24, 2001

Dear Reviewer:

Enclosed for your review and consideration is the Indiana Lake Michigan Coastal Program Document/Draft Environmental Impact Statement (P/DEIS). The P/DEIS is the second draft document released for public input. It describes the Indiana Lake Michigan Coastal Program (LMCP) and details how the program meets the requirements to participate in the Coastal Zone Management Program in partnership with the National Oceanic and Atmospheric Administration (NOAA). Chapter 15 details the public comments received and any changes made since the first document was released. The P/DEIS will form the basis for the Final Environmental Impact Statement

The LMCP was developed on the strength of Indiana's existing state laws and programs. The benefits of participation in the Coastal Zone Management Program include improved coordination in the management of natural and cultural resources of the coastal region, funding for projects and programs that address coastal resource protection and development, and technical assistance to address the coastal resource concerns of northwest Indiana.

Written comments on the P/DEIS should be submitted by November 5, 2001 to either:

John King
Chief, Coastal Programs Division
National Oceanic and Atmospheric Administration
SSMC4, Room 11537
1305 East-West Highway
Silver Spring, MD 20910

Laurie Rounds
Attn: Indiana Lake Michigan Coastal Program Comments
Indiana Department of Natural Resources
402 West Washington Street; Room W264
Indianapolis, IN 46204

The Indiana Department of Natural Resources and NOAA will hold public hearings to accept comments on the P/DEIS. These meetings will be held at 7 p.m. local time at the following locations:

- October 1, 2001 Holiday Inn 5280 S. Franklin Street, Michigan City, Indiana
- October 3, 2001 Wicker Park 8554 Indianapolis Boulevard, Highland, Indiana
- October 4, 2001 Portage Yacht Club 1370 State Road 249, Portage, Indiana

In addition, the Department of Natural Resources will hold an open house on October 2, 2001 at the Indiana Dunes State Park Nature Center from 3:00 p.m. to 7:00 p.m. Indiana Dunes State Park is located at 1600 North 25 East; Chesterton, Indiana. Representatives of the Department of Natural Resources will be available during the open house to answer questions about the Lake Michigan Coastal Program. There will also be copies of the P/DEIS and other program documents available.

For additional information on the P/DEIS, please feel free to contact me at (317) 233-0132; or you may call toll free in Indiana at (877) 928-3755. Additional information and program documents are available at http://www.in.gov/dnr/lakemich .

Sincerely,

Laurie Rounds
Lake Michigan Coastal Program

List of Federal Agencies Receiving P/DEIS

Ms. Pearl Young
Director, Office of Federal Activities (2251)
Environmental Protection Agency
NEPA Compliance Division
Mail Code 2252-A, 401 M Street, SW
Washington, D.C. 20460

Robert H. Wayland III
Director
Office of Wetlands, Oceans and Watersheds
U.S. Environmental Protection Agency
401 M Street S.W. Mail Stop 4501-F
Washington, D.C. 20460

Jim Burgess
Chief
Office of Habitat Conservation, F/HP1
SSMC3 Rm. 12752
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

David Evans
Deputy Assistant Administrator
SSMC3 Rm. 14564
National Marine Fisheries Service, FX1
1315 East-West Highway
Silver Spring, MD 20910

Richard Legatski
HDQ Legislative Affairs
HCHB Rm. 5221
14th and Constitution
Washington, DC 20230

Margaret Davidson
Director
Coastal Services Center
2224 South Hobson Avenue
Charleston, S.C. 29405-2413

Ronald C. Baird
National Sea Grant Program
R/OR1 MD1000
SSMC3 Rm. 11716
1315 East-West Highway
Silver Spring, MD 20910

Connie Barclay
Public Affairs Office
National Ocean Service
Rm. 13231, SSMC 4
1305 East-West Highway
Silver Spring, MD 20910

Director
Office of Environmental Policy and Compliance
US Department of the Interior
Mail Stop 2340
1849 C Street N.W.
Washington, D.C. 20240

Committee Chair
Senate Committee on Commerce, Science
and Transportation Subcommittee on
Oceans and Fisheries
428 Senate Hart Office Building
Washington, D.C. 20510

Committee Chair
Senate Subcommittee on Oceans and Fisheries
566 Dirksen Senate Office Building
Washington, D.C. 20510

Committee Chair
House Resources Committee
Subcommittee on Fisheries,
Ocean and Wildlife
805 O'Neill House Office Building
Washington, D.C. 20515

Mr. Chris Mann
522 O'Neill House Office Building
Washington, D.C. 20515

Director
Federal Emergency Management Agency
Federal Center Plaza, Room 832
500 C Street, S.W.
Washington, DC 20472

Director
Council on Environmental Quality
722 Jackson Place, NW
Washington, DC 20503

Chief
Environmental Planning Division
U.S. Army Corps of Engineers
CECW-PF
20 Massachusetts Avenue, N.W.
Washington, D.C. 20314-1000

Deputy for Natural Resources
ODASD(E)
Department of Defense
400 Army Navy Drive, #206
Arlington, VA 22202-2884

Office of Chief of Naval Operation (OP-44EP1)
Department of the Navy
Hoffman Building II Room 10N67
200 Stovall St.
Washington, D.C. 20585

Mr. Dave Van Gasbeck, Chief
Environmental Planning Division
Department of the Air Force
The Pentagon, 5D381
Washington, DC 20330-1000

Director
Office of NEPA Oversight
Department of Energy
Room 3E-080, GBO96-B
1000 Independence Avenue, SW
Washington, DC 20585

Associate General Counsel
Federal Energy Regulatory
Commission, Room 9118
888 1st Street, NE
Washington, D.C. 20426

Safety Manager
Department of Health and Human Services
Cohen Building, Room 4713
200 Independence Avenue, S.W.
Washington, D.C. 20201

Environmental Coordinator
Ecosystem Management Staff
U.S. Forest Service
Department of Agriculture
Auditors Building
201 14th Street, S.W.
Washington, DC 20250

Environmental Coordinator
Natural Resources Conservation Service
P.O. Box 2890 Rm. 6159
Washington, DC 20013

Director
Office of Environment and Energy
Department of Housing and Urban Development
451 Seventh Street, S.W.
Washington, D.C. 20410-7000

Chief
Environmental and Natural Resources Division
Department of Justice
8th Floor, Room 870
Washington, DC 20530

Administrator
Federal Aviation Administration
Room 3212 Nassif Building
400 Seventh Street, SW
Washington, DC 20590

Office of Technology Assessment
Maritime Administration
Code 820, Room 7209
400 Seventh Street, SW
Washington, D.C. 20590

Mr. David Reese
Environmental Protection Branch
United States Coast Guard
2100 2nd Street, SW
Washington, D.C. 20593

Ron Kilroy
CMDT (G-LEL)
U.S. Coast Guard
2100 Second Street, S.W.
Washington, D.C. 20593

Amy Brown, Office of General Counsel (LR)
General Services Administration
18th & F St., N.W. Rm 4134
Washington, D.C. 20405

Hampton Newsome
Nuclear Regulatory Commission
Office of General Counsel
Mail Stop 15B-18
Washington, DC 20555

Assistant Secretary for Economic Development
Economic Development Administration
U.S. Department of Commerce
Herbert C. Hoover Building
14th Street and Constitution Avenue, N.W.
Washington, DC 20230

Director
Federal Maritime Commission
800 North Capitol Street, N.W.
Washington, DC 20573

Daniel Injerd, Chief
Lake Michigan Management Section
Illinois Dept. of Transportation
Division of Water Resources
310 South Michigan Avenue, Rm 1606
Chicago, Illinois 60604

Anthony McDonald
Executive Director
Coastal States Organization
444 N. Capitol Street, NW
Suite 322
Washington, DC 20001

Chief of Naval Operations
Crystal Plaza #5, Room 680
2211 South Clark Place
Arlington, VA 22244-5108

Kimberly Depaul

Office of Chief of Naval Operations (N456)
Crystal Plaza 5, Room 680
Arlington, VA 22244-5108

Charles W. Challstrom
NCRP N/CG1 SSMC3 Rm. 8657
1315 East-West Highway
Silver Spring, MD 20910

Gary Matlock
National Centers for Ocean Science
SSMC4 13th Floor
1305 East-West Highway
Silver Spring, MD 20910

Dr. Michael J. Donahue
Great Lakes Commission
The Argus II Building
400 S. Fourth Street
Ann Arbor, MI 48103

Kevin Pierard
Watersheds and Nonpoint Source Branch
Water Division, EPA
77 W. Jackson Blvd.
Chicago, IL 60604

Kevin E. Heanue, HEP-1
Director, Office of Environment and Planning
Federal Highway Administration, Room 3212
400 7th Street, S.W.
Washington, DC 20590

Appendix F: List of Local, State, and Federal Agencies and Organizations Receiving Information During the Public Comment Period for the LMCP Scoping Document and P/DEIS

TITLE	ORGANIZATION
Quality Control Department	American Maize Products Co.
Director	Aquatic Resources Institute
MCACC member	B & E Marine
Attorney	Beckman, Kelly and Smith
Administrator	Bethlehem Steel Corp, Burns Harbor Division
Environmental Affairs	Bethlehem Steel Corp, Burns Harbor Division
Council Members	Beverly Shores Council
Council President	Beverly Shores Council
Owner	Blue Water Bait & Tackle
Hunting/Fishing License Dealer	Blyth's Sports Shop
Hunting/Fishing License Dealer	Briar East True Value
Environmental Affairs	British Petroleum-AMOCO Refinery
Park Manager	Buckley Homestead County Park
Director	Burns Harbor Activity Assoc.
Council Member	Burns Harbor Council
Council President	Burns Harbor Council
President	Calumet Colleges St. Joseph
Executive Director	CDC of Greater Michigan City
Town Manager	Cedar Lake- Town of
Director	Chanute Aquatorium Society
NIRPC Executive Board	Chesterton Clerk-Treasurer
Council President	Chesterton Town Council
Reporter	Chesterton Tribune
President	Citizens for Rail Trails
Director	Colonial Williamsburg Foundation
Director	Copywrite Communications LLC
Owner	Country Bait Shop
Executive Director	Crown Point Chamber of Commerce
Mayor	Crown Point City Hall
Owner/Operator	Dawn to Dusk
Owner	Doyne's Marine, INC.
Council Members	Dune Acres Town Council
Council President	Dune Acres Town Council
President	Duneland Beach Association
Executive Director	Duneland Chamber of Commerce
Executive Committee Member	Duneland Sierra Club
Program Director/Ecologist	Duneland Sierra Club
Plant Manager	DuPont Chemicals
President	Dyer Chamber of Commerce
Administrator	Dyer Planning/Zoning Administrator
Council Vice President	Dyer Town Council
Town Council Members	Dyer Town Council

TITLE	ORGANIZATION
Director of Parks and Recreation	Dyer- Town of
Council Member At-Large	East Chicago City Council
Council Members	East Chicago City Council
City Engineer	East Chicago- City of
Mayor	East Chicago- City of
Planner	East Chicago- City of
Superintendent	East Chicago Parks & Recreation
City Planner	East Chicago Planning Department
Public Information	East Chicago Public Library
Director	East Chicago Public Transit
Director	East Chicago Waterway Management District
Director	Economic Dev. Planning
Hunting/Fishing License Dealer	Fetlas Bargain Center
Member	Foundations of East Chicago
Information Officer	Friends of Indiana Dunes
Store Manager	Gander Mountain
Assistant Director	Gary Air & Land Pollution Control
Director	Gary Boat & Yacht Club
Executive Director	Gary Chamber of Commerce
Attorney	Gary City Council
Council Member At-Large	Gary City Council
Council Members	Gary City Council
Chief of Staff	Gary- City of
City Engineer	Gary- City of
City Planner	Gary- City of
Director of Planning	Gary- City of
Director of Public Works	Gary- City of
Director, Parks Dept.	Gary- City of
Environmental Consultant	Gary- City of
Mayor	Gary- City of
Waterfront Development Special Assistant to the Mayor	Gary- City of
New Department	Gary Crusader
Member	Gary Historical and Cultural Society
Resource Manager	Gary Public Library-- Indiana Room
Director of Operations	Gary Public Transportation Corporation
Executive Director	Grand Calumet Task Force
President	Great Lakes Cons., Rod and Gun Club
President	Great Lakes Engineering, L.L.C
Managing Editor	Great Lakes Publishing
President	Griffith Chamber of Commerce
Griffith Historical Society	Griffith Historical Park and Museum
Council Members	Griffith Town Council
Council President	Griffith Town Council
Griffith Clerk-Treasurer	Griffith Town Hall
Executive Vice President	Hammond Chamber of Commerce
Council Members	Hammond City Council
Asst. Chief Engineer	Hammond- City of

TITLE	ORGANIZATION
City Controller	Hammond- City of
City Engineer	Hammond- City of
City Planner	Hammond- City of
Director Economic Development	Hammond- City of
Director of Development	Hammond- City of
Mayor	Hammond- City of
Director	Hammond Department of Environmental Management
Director	Hammond Environmental Health Department
Director	Hammond Marina
Superintendent	Hammond Parks & Recreation
President	Hammond Parks Board
Director	Hammond Public Library
Hammond Historical Society	Hammond Public Library
Representative Rebecca Gutowsky	Hammond Representative
Director	Hammond Transit System
License Dealer	Hebron Marathon
Council Members	Hebron Town Council
Executive Director	Highland Chamber of Commerce
President	Highland Historical Society
Council President	Highland Town Council
Director of Public Works	Highland- Town of
President	Historic Landmarks Foundation of Indiana
Executive Director	Hobart Chamber of Commerce
City Engineer	Hobart- City of
Mayor	Hobart- City of
Recreation Director	Hobart- City of
President	Hobart Historical Society
Director	Hobart Water Watchers
Captain	Holly Lynn Fishing Charters
President	Hoosier Coho Club
Executive Director	Hoosier Environmental Council
Director	Hoosier Prairie Committee
Director	IL-IN Sea Grant Program
NW Indiana Representative	IL-IN Sea Grant Program
President	Indiana B.A.S.S. Federation
Director, Community Dev. Div.	Indiana Department of Commerce
Director, Tourism & Film Dev.	Indiana Department of Commerce
Commissioner	Indiana Department of Environmental Management
Director, Northwest Office	Indiana Department of Environmental Management
Commissioner	Indiana Department of Transportation
Deputy Commissioner	Indiana Department of Transportation
District Director	Indiana Department of Transportation LaPorte Director
Management Assistant	Indiana Dunes National Lakeshore
Superintendent	Indiana Dunes National Lakeshore
Director, Development and Natural Resources Division	Indiana Farm Bureau
Field Representative- Lake and Porter Counties	Indiana Farm Bureau
Field Representative- LaPorte County	Indiana Farm Bureau

TITLE	ORGANIZATION
President	Indiana Farm Bureau
Associate Director	Indiana Geological Survey
Executive Director	Indiana Port Commission
Port Director	Indiana Port Commission
Associate Editor	Indiana Prairie Farmer
Environmental Sec. Liaison	Indiana State Bar Assoc.
State Health Commissioner	Indiana State Department of Health
Executive Director	Indiana State Emergency Management Agency
State Treasurer	Indiana State Treasurer's Office
Chancellor	Indiana University Northwest
Calumet Regional Archivist	Indiana University Northwest Library
Executive Director	Indiana Wildlife Federation
Outdoor Editor	Indianapolis Star
President	Indiana's North Coast Charter Association
Senior Editor	INGroup
Manager, Safety & Environ. Affairs	Inland Steel Company
Director	International Friendship Gardens
International Vice President	International Longshoremen's Association
Manager of Environmental Projects	Ivy Tech Community College
Indiana Division President	Izaak Walton League
Treasurer	Jack's Loan Office, INC
Owner	Jim Shema's Outdoor Sports
Owner	Kempf Gun Shop
Clerk Treasurer	Kingsford Heights Clerk-Treasurer
Public Relations	Kouts Chamber of Commerce
Council Member	Kouts Town Council
Representative	Lake County Central Labor Union
County Commissioners	Lake County Commission
Board Member	Lake County Convention and Visitors Bureau
Executive Director	Lake County Convention and Visitors Bureau
Council Members	Lake County Council
Council President	Lake County Council
Director	Lake County Courthouse Foundation
President	Lake County Fish and Game Protective Assc.
Lake County Treasurer	Lake County Government Center
Director	Lake County Historical Society
Director	Lake County Parks & Recreation Department
Superintendent	Lake County Parks & Recreation Department
Director	Lake County Planning Commission
Director	Lake County Public Library
Resource Conservationist	Lake County S.W.C.D.
Director	Lake County Sheriff's House Foundation
Executive Director	Lake County Solid Waste District
Surveyor	Lake County Surveyor's Office
Treasurer	Lake County Treasurer
Director	Lake Michigan Federation
President	Lake Michigan Sport Fishing Coalition

TITLE	ORGANIZATION
Owner	Lake Michigan Tackle
President	Lake Station Chamber of Commerce
Council Members	Lake Station City Council
Councilman at Large	Lake Station City Council
Fire Chief and Council Member	Lake Station City Council
City Engineer	Lake Station- City of
Clerk Treasurer	Lake Station- City of
Mayor	Lake Station- City of
Superintendent, Parks & Recreation Dept.	Lake Station- City of
President	Lake Station Historical Society
Owner	Lakeside Sports
Mayor	LaPorte- City of
County Planner/ Human Resource Director	LaPorte County
Historian	LaPorte County
County Commissioners	LaPorte County Commission
Community Relations Coordinator	LaPorte County Convention and Visitors Bureau
Director	LaPorte County Convention and Visitors Bureau
Executive Director	LaPorte County Convention and Visitors Bureau
Council Members	LaPorte County Council
Council President	LaPorte County Council
LaPorte County Surveyor	LaPorte County Courthouse
President	LaPorte County Historical Society, Inc.
Superintendent	LaPorte County Parks Department
Surveyor	LaPorte County Surveyor
Secretary	LaPorte County SWCD
Manager of Environmental Compliance	LaSalle Steel Company
President	Latino Historical Society
Assoc. Director of Transportation	LCEOC, Inc.
Information Officer	League of Women Voters
Owner	Lefty's Coho Landing, Inc.
Plant Manager	Lever Brothers Company
Hessville Historical Society	Little Red Schoolhouse
Council Members	Long Beach Town Council
Council President	Long Beach Town Council
Director of Administration	Lowell- Town of
Manager	LTV Steel
Hunting/Fishing License Dealer	Main Street Outdoor Sports
President	Marktown Preservation Society
President	Merrillville Chamber of Commerce
Council Members	Merrillville Town Council
Council President	Merrillville Town Council
Merrillville Clerk Treasurer	Merrillville- Town of
Merriville Town Manager	Merrillville- Town of
President	Merrillville, Ross Twp. Historical Society
NIRPC-EMPC Member	Methodist Hospital
Council Members	Michiana Council
Council President	Michiana Council

TITLE	ORGANIZATION
President	Michiana Steelheaders
Mayor	Michigan City
Member Services Coordinator	Michigan City Chamber of Commerce
President	Michigan City Charter Association
Captain	Michigan City Charter Boat Association
Council Member At-Large	Michigan City Council
Council Members	Michigan City Council
Council President	Michigan City Council
President	Michigan City Historical Society, Inc.
Reporter	Michigan City News Dispatch
Superintendent	Michigan City Parks & Recreation
Director	Michigan City Port Authority
Owner	Mik-Lurch Bait & Tackle
NIRPC-EMPC Member	Mirant Industry
Executive Director	Munster Chamber of Commerce
Director, Parks & Recreation Dept.	Munster- City of
Munster Clerk-Treasurer	Munster Clerk-Treasurer's Office
President	Munster Historical Society
Council Members	Munster Town Council
Council President	Munster Town Council
Town Engineer	Munster- Town of
Town Manager	Munster- Town of
Chairman	Natural Resources Commission
Commission Members	Natural Resources Commission
Lake Michigan Regional Program Director	Nature Conservancy
State Director	Nature Conservancy
Council Members	New Chicago Council
Council President	New Chicago Council
Clerk Treasurer	New Chicago Water
Director of Marketing and Planning	NICTD
General Manager	NICTD
Executive Director	NIRPC
NIRPC Commission Members	NIRPC Commission
Coordinator	NiSource
Environmental Coordinator	NiSource
Environmental Specialist	NiSource
Program Leader	NiSource
Economic Development	Northwest Indiana Forum
Environmental Consultant	Northwest Indiana Forum
President	Northwest Indiana Forum
President	Northwest Indiana Genealogy Society
Director	Northwest Indiana Steelheaders
Underground Railroad	Northwest Region
Senior Administrative Assistant	Northwestern Indiana Regional Planning Commission
Trails Interest	NW IN Trails Advocate
President	NW Indiana Bass
Coordinator	NWIN Brownfields Redev. Project Inc.

TITLE	ORGANIZATION
Director of Natural Resources	Office of Communications of Agriculture
Executive Assistant	Office of Lt. Governor
Lieutenant Governor	Office of the Lieutenant Governor
Council Members	Ogden Dunes Council
Council President	Ogden Dunes Council
Director	Old Lighthouse Museum
Editor	Outdoor Writers
Captain	Pair A Dice Charters, INC
Director	Pastrick Marina
Vice President	Perch America
Councilman	Pines Clerk-Treasurer
Council Members	Pines Town Council
Council President	Pines Town Council
Executive Director	Portage Chamber of Commerce
City Engineer	Portage- City of
Superintendent	Portage Parks & Rec. Dept.
Director	Portage Port Authority
Director	Portage Public Marina
Council Member At-Large	Portage Town Council
Council Members	Portage Town Council
City Clerk	Portage Town Hall
Mayor	Portage- Town of
Assessor	Porter County Assessor
County Commissioner	Porter County Commission
Chairman, Visitor Center Committee	Porter County Convention, Recreation & Visitors Commission
Director	Porter County Convention, Recreation & Visitors Commission
Director, Public Relations	Porter County Convention/Rec Comm.
Council Member At-Large	Porter County Council
Council Members	Porter County Council
Council President	Porter County Council
Administrator	Porter County Extension Office
Porter County Commissioners	Porter County Hall
Porter County Treasurer	Porter County Hall
Chapter Contact	Porter County Izaak Walton League
Superintendent	Porter County Parks
Director	Porter County Planning
Director	Porter County Solid Waste District
Surveyor	Porter County Surveyor
District Administrator	Porter County SWCD
Coordinator	Porter County. Environ. Dept.
Executive Director	Porter Plan Commission
Council Members	Porter Town Council
Council President	Porter Town Council
Director, Public Works	Porter- Town of
City Planner	Porter- Town of; Plan Commission
Publisher	Post-Tribune
Reporter	Post-Tribune

TITLE	ORGANIZATION
President	Potawatomi Audubon Society
Chairman	Purdue CES
LaPorte County Extension Office	Purdue CES
President	Purdue University Calumet
President	Purdue University North Central
Professor of Biology	Purdue University North Central
Hunting/Fishing License Dealer	Qwik Step Outdoors
Hunting/Fishing License Dealer	Range Master Outfitters, INC.
Co-Owner	Reel Deal Bait & Tackle
Woodlands Communications Group	Region Watch
Assistant Director	Rogers- Lakewood Park
Owner	Rudy's Bait Shop
Member	S.T.O.P
President	Salmon Unlimited Indiana
Treasurer	Salmon Unlimited of Indiana
Director	Save the Dunes Conservation Fund
Executive Director	Save the Dunes Council
President	Schererville Historical Society
Council President	Schererville Town Council
Town Manager	Schererville- Town of
Council President	Schneider Town Council
Executive Director	Shirley Heinze Environmental Fund
Trustee	Shirley Heinze Fund Trustee
Coordinator	South Shore Clean Cities Coalition
President	Sportsmen of Northern Indiana
Council President	St. John Town Council
Manager	Stan's Bait and Tackle
Representative Charles F. Dobis	State Representative
Representative Charlie Brown	State Representative
Representative Dan Stevenson	State Representative
Representative Daniel Dumezich	State Representative
Representative Duane Cheney	State Representative
Representative Earl Harris	State Representative
Representative Gary Cook	State Representative
Representative John Aguilera	State Representative
Representative John Pugh	State Representative
Representative Linda Lawson	State Representative
Representative Mary Kay Budak	State Representative
Representative Mel Fath	State Representative
Representative Michael D. Smith	State Representative
Representative Paul Doherty	State Representative
Representative Ralph D. Ayres	State Representative
Representative Robert Kuzman	State Representative
Representative Roger Chiabai	State Representative
Representative Vernon G. Smith	State Representative
RepresentativeScott D. Pelath	State Representative
Senator Anita O. Bowser	State Senator

TITLE	ORGANIZATION
Senator Earline Rogers	State Senator
Senator Frank Mrvan, Jr.	State Senator
Senator Rose Ann Antich	State Senator
Senator Sam Smith, Jr.	State Senator
Senator Sue Landske	State Senator
Senator William Alexa	State Senator
Environmental Reporter	The Times
Executive Editor	The Times
Staff Writer	The Times
Clerk Treasurer	Trail Creek Clerk Treasurer
Council Members	Trail Creek Town Council
Council President	Trail Creek Town Council
Chicago District	U.S. Army Corps of Engineers
Louisville District	U.S. Army Corps of Engineers
State Director	U.S. Coast Guard Auxiliary
Director	U.S. Dept. of Commerce
Regional Team Manager	U.S. EPA - Region 5
Director	U.S. EPA, Great Lakes Nat'l Program Office
Division Administrator	U.S. Federal Highway Admin.
Biologist	U.S. Fish & Wildlife Service
Supervisor	U.S. Fish & Wildlife Service
Water Resources Division	U.S. Geological Survey
Biologist	U.S. National Biological Survey
State Conservationist	U.S. Natural Resources Conservation Service
District Conservationist	U.S. NRCS
Resource Conservationist, LaPorte County	U.S. NRCS District USDA
Representative Peter J. Visclosky	U.S. Representative
Representative Tim Roemer	U.S. Representative
Senator Richard Lugar- District Office	U.S. Senator
Senator Richard Lugar- Washington D.C. Office	U.S. Senator
Senator Evan Bayh	U.S. Senator District Office
Senator Evan Bayh	U.S. Senator Washington Office
Environmental Control	U.S. Steel
Environmental Control	U.S. Steel
Environmental Technician	Union Carbide Industrial
Director	Urban Enterprise Association
President	Urban League of NWI, Inc.
Manager, Government Affairs	USX Corp., Gary Works
President	Valparaiso Chamber Of Commerce
Council Member At-Large	Valparaiso City Council
Council Member President	Valparaiso City Council
Council Members	Valparaiso City Council
City Engineer	Valparaiso- City of
Director, Parks & Recreation Dept.	Valparaiso- City of
Economic Development Planner	Valparaiso- City of
Historic Preservation Commission Member	Valparaiso- City of
Mayor	Valparaiso- City of

TITLE	ORGANIZATION
Public Information	Valparaiso Public Library
President	Valparaiso University
President	Veterans Memorial Parkway Commission
Town Council President	Wanatah City Council
Representative	Wanatah Representative
Harbor Master	Washington Park Marina
Owner	Westforth Sports
Executive Director	Whiting Chamber of Commerce
Council Members	Whiting City Council
Council President	Whiting City Council
City Engineer	Whiting- City of
City Planner	Whiting- City of
Mayor	Whiting- City of
Director	Whiting-Robertsdale Historical Society
Council President	Winfield Town Council
Director	Wings Over Water

Appendix G: Coastal Processes Affecting Indiana's Lake Michigan Shoreline

Lake Michigan is the second largest of the Great Lakes and lies entirely within the United States. It borders 4 states, Michigan, Wisconsin, Illinois and Indiana (Figure 1). Lake Michigan covers 234.5 square miles of the northwest corner of the state of Indiana, and 45 miles of its coast are also within the state boundaries.

Figure 1: States surrounding Lake Michigan

The physiography of the Lake Michigan drainage basin is the expression of surficial sediments deposited during the late Pleistocene and Holocene Epochs. Lakebed deposits in the southern part of Lake Michigan, including the portion of the lake that lies within the state of Indiana, include sand near the shore, gravel from 50 to 100 feet deep, and mud in the deep parts. Elongated sand dune ridges landward of the south shore of Lake Michigan represent late Pleistocene and Holocene shorelines of ancestral Lake Michigan. Three beach ridges occur in the lacustrine plain and are major dune and beach complexes that developed during periods of high semi-stable lake level. These ridges, moving lakeward, are the Glenwood Beach, the Calumet Beach, and the Toleston Beach.

The Glenwood Beach is the highest dune and beach complex but is a discontinuous ridge. The crest of this dune and beach complex has an average elevation of about 650 feet above mean sea level. However, foreshore deposits, which represent the paleoshoreline, are present in places between 620 and 630 feet above mean sea level.

The Calumet Beach is lakeward of the Glenwood Beach. Dune-capped areas in this complex have an average elevation of about 630 feet above mean sea level, and the foreshore deposits have an average elevation of 607 feet above mean sea level. Calumet Beach deposits consist of dune sediments overlying beach and nearshore sediments.

The Toleston Beach is the youngest dune and beach complex in Indiana. The landward part of this complex consists of linear ridges of coalesced parabolic dunes separated by interdunal swamps, and the lakeward portion is comprised of large dome-shaped and small parabolic dunes, as well as over 150 beach ridges in its western part. Elevations at the top of large domal dunes are as much as 750 feet above mean seal level. Foreshore, upper shoreface, and back-barrier lacustrine deposits occur in the internal core of the complex. The top of the foreshore sequence of the Toleston Beach ranges from 597 to 603 feet above mean sea level. Modification of the Toleston Beach is still occurring in the eastern part of the region because of the reorientation of dominant wind direction across Lake Michigan.

Wetlands of considerable size are present in the interridge depressions in the eastern part of the Indiana Lake Michigan region. Palustrine sediments are abundant in these interridge wetlands. Areas along the lacustrine plain are capped by lacustrine and palustrine sediments. These areas are drained by sluggish rivers that empty into Lake Michigan. However, extensive channelization of the Little and Grand Calumet Rivers and industrialization in neighboring areas have altered the physiography and the hydrology of the region.

Several studies have been conducted on Lake Michigan to gain an understanding of coastal processes. The following information about the coastal processes of Lake Michigan was taken from the 1998 State of Indiana Coastal Situation Report. The 1998 report was an update and enhancement to the 1988 Coastal Situation Report produced by the Purdue University Great Lakes Coastal Research Lab. The following information is presented from the 1998 Coastal Situation Report:

- Wave and Current Regimes of Lake Michigan
- Wave Climatology
- Storms and Lake Michigan
- Coastal Protection and Structures
- Shoreline Change Over Time

Indiana's coastline is divided into five littoral cells, each separated from the other by an engineered primary structure. Figure 2 shows these littoral cells (CZM, Reach 1 and 2 combined, Reach 3, Reach 4, Reach 5) separated by the four primary structural barriers, Michigan City Harbor, Port of Indiana/Bethlehem Steel Industrial Complex, US Steel/Gary Harbor, and Indiana Harbor respectively, each of which traps or diverts to deeper water essentially all of the sediment transported in the adjacent littoral cells. It is important to note that the net movement of sand occurs in two directions along Indiana's shoreline. On the eastern portion of Indiana's shoreline (from Michigan to Gary, Indiana) net sediment movement is from the east toward the west. In contrast, on the western portion of Indiana's shoreline (from Illinois to Gary, Indiana) the net sediment movement is from the west toward the east.

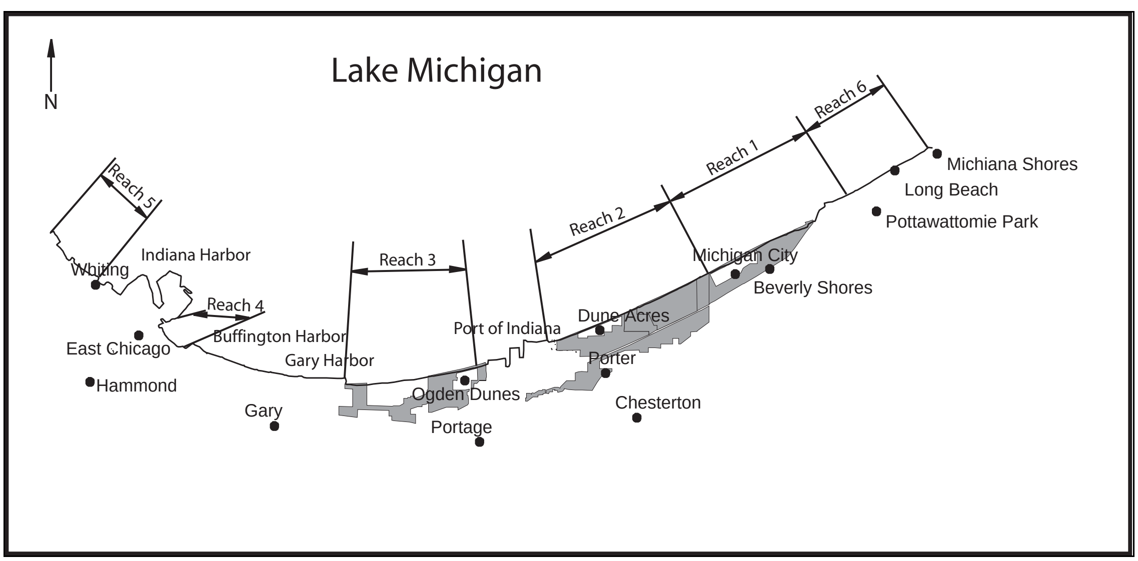


Figure 2: Reaches Along Indiana's Shoreline

WAVE AND CURRENT REGIME OF LAKE MICHIGAN

In order to fully understand the discussion presented in the following sections, it is necessary to first have a clear understanding of coastal processes (involving sand and water movement) and how they respond to physical forces (wind and waves) in southern Lake Michigan. Coastal process/response systems of the Great Lakes are generally much more dynamic than their oceanic counterpart. The primary reason for this more dynamic behavior is that mean still water level (MSWL) on the Great Lakes is in a constant state of change. Fluctuations in Lake Michigan's lake-level occur on both short (1 year) and long (multiple year) time scales and are not symmetric (Figure 3). Thus, the annual average position of MSWL varies from year to year. This annual average variation of MSWL causes an imbalance in the coastal process/response system forcing it to readjust. A change in MSWL does not, by itself, cause erosion or deposition readjustment in the coastal zone. It does, however, modulate wind-wave energy, which is the principal source of physical forcing responsible for coastal sediment movement.

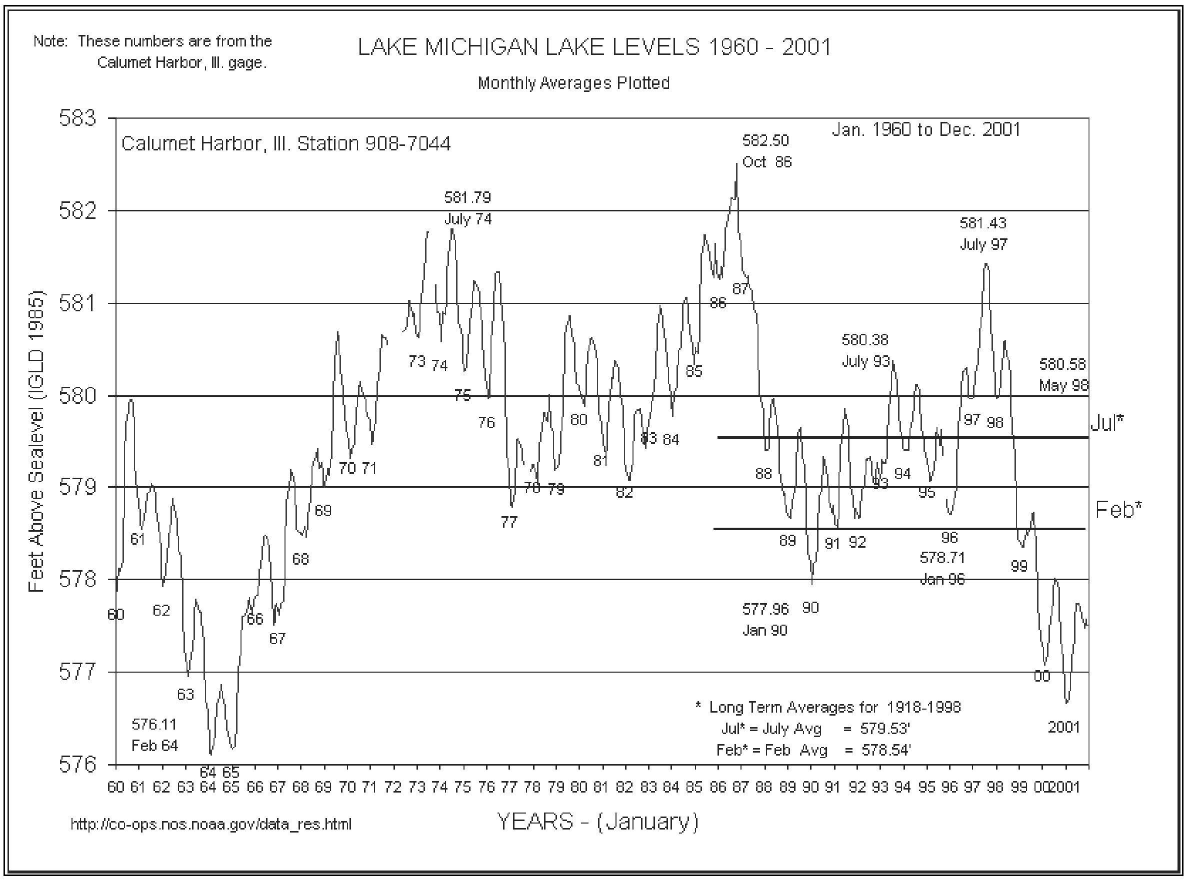


Figure 3: Lake Michigan Lake Levels 1960- 2000

Currents

The primary driving force of Lake Michigan waves and currents is wind. Wind energy transferred to the lake surface is partitioned such that approximately 95% goes into the generation of currents and 5% generates waves (Meadows, 1986). On Lake Michigan, as on all the Great Lakes, wind systems responsible for driving waves and currents are highly variable. Thus, unlike the ocean, currents on Lake Michigan are quite transient both with respect to speed and direction.

Surface circulation of Lake Michigan is poorly known, especially in offshore regions, between 30 and 75 feet of water depth, close to shore. A comprehensive study on currents and water masses of Lake Michigan by Ayers et al. (1958) indicated a persistent southerly drift along the southeastern shore of the lake, but found the rest of the currents to be more variable. Verber (1965) measured current speed at various depths in Lake Michigan. He found that in the offshore region, the average velocity was 0.45 ft/sec and that current speed decreased rapidly below those depths. Current speeds were found to be nearly twice as high during winter and early spring as they were in the summer. Verber (1964) also found that water at the 100-foot level in the southern basin rotated alternately clockwise and counter-clockwise in response to the surface winds. Regardless of the variability of lake circulation, this is not the current system responsible for sediment transport in the nearshore. This point is often confused when explanations are sought for observed coastal erosion and deposition patterns or trends. The currents responsible for beach erosion and nearshore sediment transport are generated by breaking waves at the coast in water depths from –20 feet to water's edge. This area of water between –20 feet to the beach is referred to as the "breaking wave zone".

Waves at the Coast

Wind-Wave Generation in Southern Lake Michigan

Wind-waves are generated in all directions over the lake surface in direct response to the prevailing atmospheric pressure system. Figure 4 shows a wind rose constructed from the National Oceanic and Atmospheric Administration (NOAA) buoy data (45007) taken from 1981 to 1996. The prevailing southerly winds, characteristic of Indiana's coastline, are clearly delineated by these data. However, these southerly winds do not generate waves that impinge on the coast of Indiana. Waves which are responsible for coastal erosion and sediment transport along the coast are generated by winds from the west, northwest, north, and northeast. Most notable in the data for these four wind directions is the large percentage of velocities in excess of 10 knots (Figure 4). Winds greater 10 knots are important because they are capable of generating waves large enough to carry sediment along the coast.

"Significant wave height" values were calculated for each of the directions and wind velocity ranges that would generate erosive waves along Indiana's coastline. These calculated "significant wave height" values are the average height of the highest 33% of waves arriving offshore, at the coast. This means that maximum wave heights will exceed these values. These calculated wave heights are shown in Table 1.

	Wind Speed (Knots)			
Wind Direction From:	11-15	16-20	21-25	26-30
West	2.8	4.0	5.0	6.1
Northwest	3.7	7.0	8.9	10.5
North	3.7	6.0	7.6	9.2
Northeast	2.0	2.8	3.6	4.3

Table 1: Calculated "significant wave height" values, in feet, for wind generated waves impinging on the Indiana coastline. Wave heights are for unbroken offshore waves arriving at the coast.

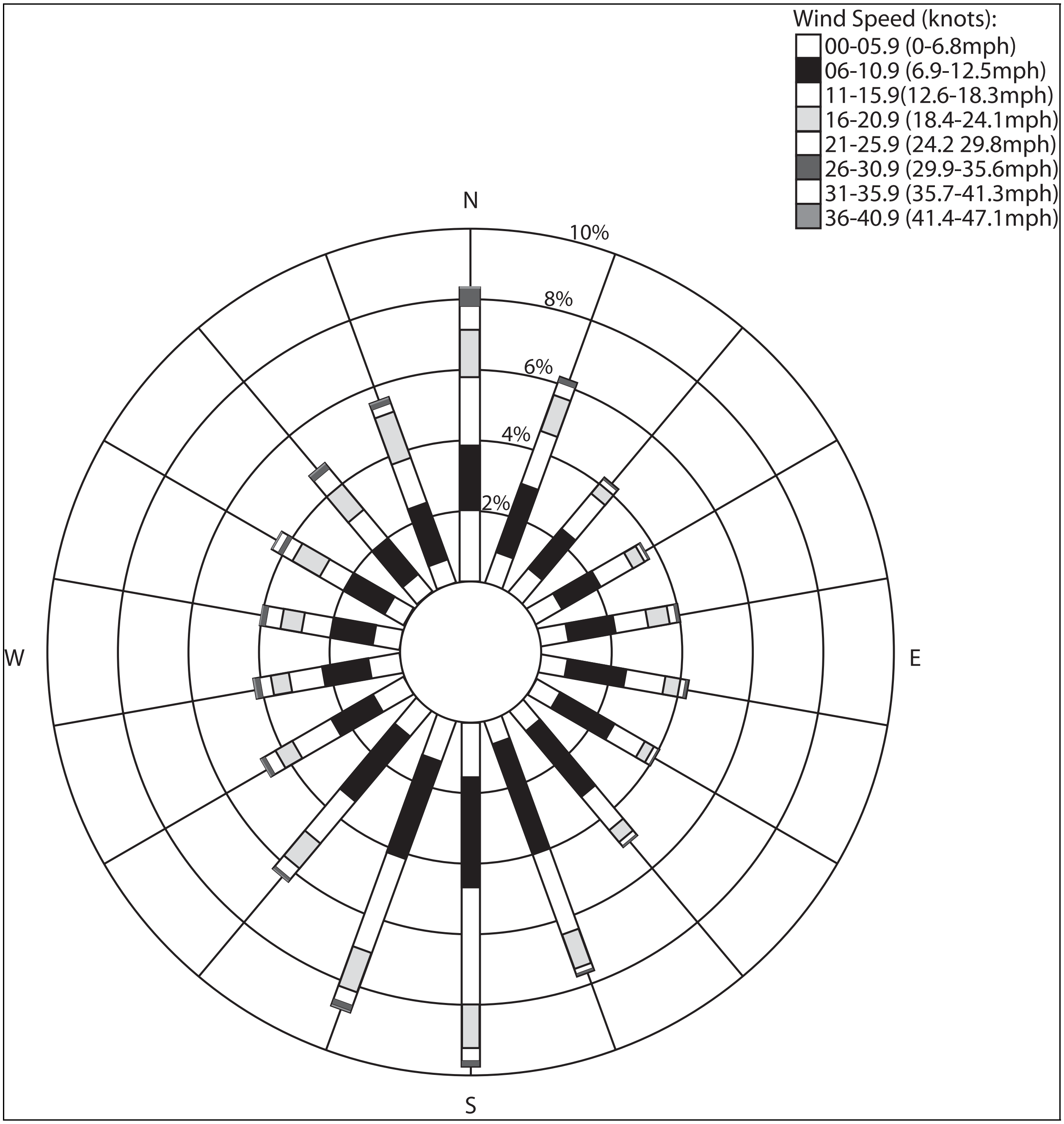


Figure 4: Wind Rose for Southern Lake Michigan (Bars indicate direction wind blows from)

Wave Refraction and Breaking

As waves move into shallower water near the shore, the bottom of the wave begins to touch the lake bottom. This process is referred to as shoaling. The wave speed slows in such a way as to bend (refract) the wave crest to align with the shoreline. For most of the Indiana shore, this bending (refraction) tends to align the wave crests nearly parallel to the shoreline. Figure 5 shows a schematic drawing of shoaling wave crests refracting at a coast. As these waves shoal and break, they carry water mass landward, towards the beach. This rapidly moving water mass is transported in two directions (up onto the beach and parallel with the beach). If waves approach at a high angle to the shore (highly non-parallel), large quantities of water are transported along the shore forming what is called a longshore current. The velocity of the longshore current will increase with increasing wave height and higher (non-parallel) wave crest angles. The strongest longshore currents are generated when the wave crest is at a 45 degree angle to the shoreline. If waves approach at low angles (nearly parallel) to the shore, large quantities of water are carried up the beach and onto the back beach dune-bluff, but the resulting longshore current velocities will be relatively slower. This uprush of water, called swash, erodes the dune-bluff base causing slumping, and lifts sediment into suspension. Once this water mass rushes up the beach face, it reverses direction and flows rapidly lakeward (backwash) due to the acceleration of gravity. This backwash carries sediment off the beach face and into the prevailing longshore current. The water mass transported landward by breaking waves must be returned to the offshore in order to conserve mass. Stated another way, if the mass of water transported landward with each wave did not eventually return to the offshore, then water would continue to pile up on the shore.

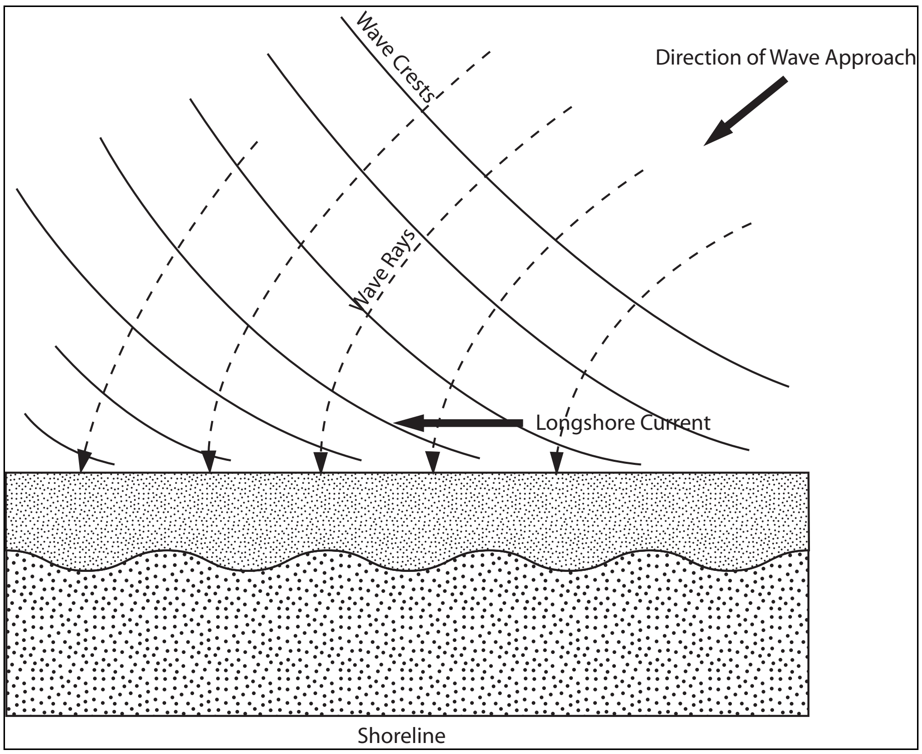


Figure 5: Wave Refraction and Longshore Current for waves approaching at 45 degrees to the shoreline.

WAVE CLIMATOLOGY

In order to better understand the coastal dynamics of the Indiana shoreline and to properly assess the impact and performance of engineered structures built at the shore, it is necessary to know the coastal wave climatology.

NOAA data buoy 45007 is located at latitude 42^{o} 42' North, longitude 87^{o} 06' West (located approximately 75 miles (statute) north of Gary, Indiana) and is maintained in Lake Michigan from early spring (March) to late fall (November) during the ice-free months. Analyses were carried out on the buoy wave data to determine a composite wave climatology and wave probability occurrence statistics.

Composite Wave Climatology

Wave height, period and direction data for years 1981 through 1996 were combined to generate composite distributions of wave height and direction and wave height and period. This data was obtained from the National Data Buoy Center (NDBC) webpage: http://seaboard.ndbc.noaa.gov.

Figure 6 gives the distribution of "significant wave heights" for 20^{o} sectors of wave approach direction for the entire reporting period. The detailed tabulation of these "significant wave height" data are given in Table 2a and 2b. Waves that would be directly incident on the Indiana shore or would refract to the shore would come from sectors in the western (265-284, 285-304, 305-324), northern (345-004, 5-24), or eastern (25-44, 45-64, 65-84) quadrants of this distribution. Evident in Figure 6 is the dominance of high wave occurrence from the north and northwest. These data support the conclusion that Indiana's coast is one of the most significant high wave energy areas in all of Lake Michigan.

There is a statistical bias in these wave data because NOAA buoys are generally deployed from March or April through November. However, these data do represent a large portion of the ice-free months with the notable exception of early winter storm waves that occur in December. The marginal distribution of Table 3 shows that a majority of observed waves are 3 feet or less in height with periods less than 6 seconds. The largest observed wave was approximately 18 feet with a period of about 7.5 seconds. The previous Coastal Situation Report (1988), which utilized data from 1981 to 1984 and 1986, also reported a maximum observed wave height of 18 feet with a period of 6 to 7 seconds.

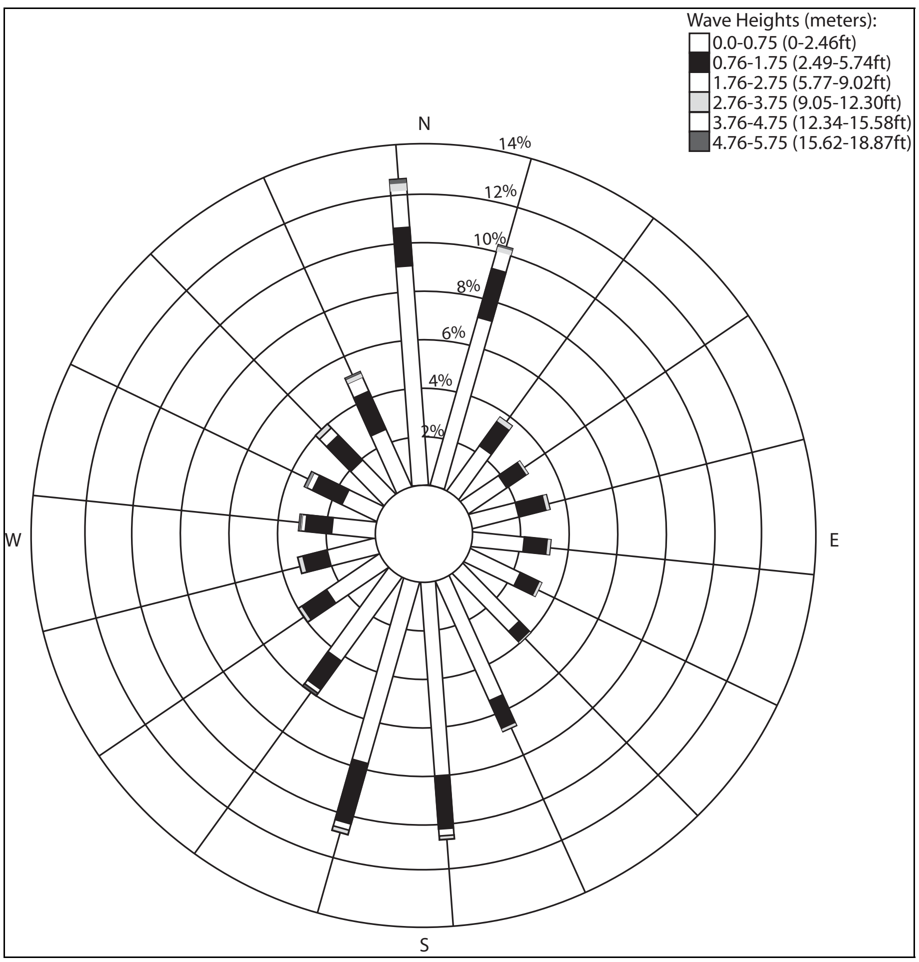


Figure 6: Wave Rose for Southern Lake Michigan (bars indicate direction from which waves are coming)

Table 2a and 2b: Joint distribution of wave direction in compass degrees relative to north (0 or 360 ^{o}) and wave height in meters. Uppermost entry is number of observations and lowermost entry is percent of all observations

Table 2a: Wave Height Data for 1981 through 1996 Buoy 45007

Buoy Location: Southern Lake Michigan at

42.7000 Latitude and 87.1000 Longitude

Wave Height	**Wave Direction (Degrees)**								
Range (m)	**005-024**	**025-044**	**045-064**	**065-084**	**085-104**	**105-124**	**125-144**	**145-164**	**165-184**
0.00-0.25	1786	776	575	616	709	857	1195	1795	2243
	2.276	0.989	0.733	0.785	0.904	1.092	1.523	2.288	2.859
0.26-0.75	2964	1123	873	1032	1060	1075	1414	2386	3694
	3.778	1.431	1.113	1.315	1.351	1.370	1.802	3.041	5.052
0.76-1.25	1658	544	453	505	498	369	405	764	1435
	2.113	0.693	0.577	0.644	0.635	0.470	0.516	0.974	1.829
1.26-1.75	828	248	207	204	135	110	163	293	503
	1.055	0.316	0.264	0.260	0.172	0.140	0.208	0.373	0.641
1.76-2.25	437	123	64	79	80	54	72	103	220
	0.557	0.157	0.082	0.101	0.102	0.069	0.092	0.131	0.280
2.26-2.75	206	46	16	24	16	17	19	53	69
	0.263	0.059	0.020	0.037	0.020	0.022	0.024	0.068	0.088
2.76-3.25	90	18	1	7	11	3	1	4	22
	0.115	0.023	0.001	0.009	0.014	0.004	0.001	0.005	0.028
3.26-3.75	58	1	0	0	4	4	0	0	5
	0.074	0.001	0.000	0.000	0.005	0.005	0.000	0.000	0.006
3.76-4.25	19	0	0	0	3	0	0	0	0
	0.024	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
4.26-4.75	11	1	0	0	0	0	0	0	0
	0.014	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.76-5.25	9	0	0	0	0	0	0	0	0
	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5.26-5.75	0	0	0	0	0	0	0	0	0
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	8066	2880	2189	2467	2516	2489	3269	5398	8461

Table 2b: Wave Height Data for 1981 through 1996 Buoy 45007

Buoy Location: Southern Lake Michigan at

42.7000 Latitude and 87.1000 Longitude

Wave Height	**Wave Direction (Degrees)**								
Range (m)	**185-204**	**205-224**	**225-244**	**245-264**	**265-284**	**285-304**	**305-324**	**325-344**	**345-004**
0.00-0.25	2355	1455	841	611	538	496	559	952	3388
	3.001	1.854	1.072	0.779	0.686	0.632	0.712	1.213	4.318
0.26-0.75	3733	1841	1224	996	866	757	933	1180	3075
	4.758	2.346	1.560	1.269	1.104	0.965	1.189	1.504	3.919
0.76-1.25	1533	749	512	484	493	532	662	772	1514
	1.954	0.955	0.653	0.617	0.628	0.678	0.869	0.984	1.930
1.26-1.75	552	331	237	285	295	387	506	515	894
	0.704	0.422	0.302	0.363	0.376	0.493	0.645	0.656	1.139
1.76-2.25	263	135	109	127	156	180	244	293	524
	0.335	0.172	0.139	0.162	0.199	0.229	0.311	0.373	0.668
2.26-2.75	75	35	36	78	87	79	136	214	208
	0.096	0.045	0.046	0.099	0.111	0.101	0.173	0.273	0.265
2.76-3.25	14	9	14	31	30	52	65	78	87
	0.018	0.011	0.018	0.040	0.038	0.066	0.083	0.099	0.111
3.26-3.75	5	3	8	5	4	15	36	37	49
	0.006	0.004	0.010	0.006	0.005	0.019	0.046	0.047	0.062
3.76-4.25	0	2	3	4	0	3	9	14	27
	0.000	0.003	0.004	0.005	0.000	0.004	0.011	0.018	0.034
4.26-4.75	0	1	1	4	1	7	6	4	19
	0.000	0.001	0.001	0.005	0.001	0.009	0.008	0.005	0.024
4.76-5.25	0	2	0	0	3	0	0	0	20
	0.000	0.003	0.000	0.000	0.004	0.000	0.000	0.000	0.025
5.26-5.75	0	0	0	0	0	0	0	1	3
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004
Total	8530	4563	2985	2625	2473	2508	3176	4060	9808

Note: Number of calm observations: 9,935; Total number of observations:78,463

Table 3: Southern Lake Michigan for 1981 through 1996							
Period	**calm**	**4.0-5.9**	**6.0-7.9**	**8.0-9.9**	**10.0-11.9**	**12.0-13.9**	**Totals**
Wave Height							
0.00-0.25	8839	1030	4	2	1	0	
	22.64	2.64	0.01	0.01	0.00	0.00	25.30
0.26-0.75	7540	5851	106	0	0	0	
	19.31	14.99	0.27	0.00	0.00	0.00	34.57
0.76-1.25	847	5845	821	0	0	0	
	2.17	14.97	2.10	0.00	0.00	0.00	19.24
1.26-1.75	20	2879	1245	19	0	0	
	0.05	7.37	3.19	0.05	0.00	0.00	10.66
1.76-2.25	0	847	1291	52	0	0	
	0.00	2.17	3.31	0.13	0.00	0.00	5.61
2.26-2.75	0	91	808	113	1	0	
	0.00	0.23	2.07	0.29	0.00	0.0	2.59
2.76-3.25	0	4	266	158	2	0	
	0.00	0.01	0.68	0.40	0.01	0.00	1.10
3.26-3.75	0	1	58	138	6	0	
	0.00	0.00	0.15	0.35	0.02	0.00	0.52
3.76-4.25	0	0	7	61	5	0	
	0.00	0.00	0.02	0.16	0.01	0.00	0.19
4.26-4.75	0	0	6	25	16	0	
	0.00	0.00	0.02	0.06	0.04	0.00	0.12
4.76-5.25	0	0	1	9	22	0	
	0.00	0.00	0.00	0.02	0.06	0.00	0.08
5.26-5.75	0	0	0	1	3	0	
	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Totals	44.17	42.39	11.82	1.48	0.14	0.00	100.00

Table 3: Joint distribution of wave height in meters and wave period in seconds for Southern Lake Michigan. Uppermost entry is number of observations and lowermost entry is percent of all observations

STORMS AND LAKE MICHIGAN

There is very little appropriate data available on wind conditions at the Indiana coast and virtually no data on waves. However, studies have been done that can provide some insight to conditions at the Indiana coast. Wind data were collected at the Ogden Dunes, U.S. Weather Bureau Cooperative Station, between 1949 and 1967. These data indicate that "prevailing" monthly wind is from the south at an annual average speed of 11 knots (12.65 mph). However, maximum recorded wind speeds for each month ranged from 44 to 74 knots (50.6 to 85.1 mph) blowing from the north, northwest, or west. The primary sustained storm periods were in early spring and late fall. It is these sustained periods of high winds from the north, northwest, and west that cause the greatest coastal erosion and dune-bluff recession in southern Lake Michigan.

Wave measurements in southern Lake Michigan close to the Indiana shoreline are essentially non-existent. Visual observations of wave height were made at selected sites along the coast of Indiana during the U.S. Army Corps of Engineers, Littoral Environmental Observation (LEO) program. These data are too subjective and intermittent to be of use in assessing wave climatology and predicting shoreline response. The U.S. Army Corps of Engineers, Coastal Engineering Research Center took limited (2 to 4 months) wave measurements off Beverly Shores, Indiana in the mid-seventies. These data indicate maximum wave heights at a distance of approximately one-half mile offshore to be between 16 and 22 feet, during extreme storm conditions. From 1981 to present the NOAA has collected wind and wave data from a southern Lake Michigan monitoring buoy 45007 (National Data Buoy Center). The buoy is located offshore of Racine, Wisconsin, approximately 75 miles (statute) north of Gary, Indiana. These data were analyzed as part the 1998 study to produce wave climatologies for the Indiana shoreline. Another source for wave data is the Wave Information Study (WIS) for Lake Michigan (Hubertz et. al., 1991), by the U.S. Army Corp of Engineers, Coastal Engineering Research Center. The WIS data provide a hindcast database for the period from 1956 to 1987.

Wave Probability Statistics

Wave probability statistics are useful while assessing proposed coastal engineering designs, calculating sediment transport and determining coastal storm risks. The sixteen years of observed wave data shown in Tables 2a and 2b were used to generate a long-term probability distribution of wave heights for the Indiana coast. The data were directionally filtered to only include those waves from 265^{o} (West) through 360^{o}, or 0^{o}, (North) to 104^{o} (East) (See Table 2a and 2b). The probabilities of the known wave height for 1981-1986 (thin line) and 1981-1995 (thick line) data are plotted as a log-probability (Weibull) distribution function in Figure 7. The "best fit" to the data is represented by the line drawn through the observed heights in Figure 7. This line can be extrapolated to the 50 or 100-year return period probability levels. The accuracy of this extrapolation is assessed by how well the data fit a straight line, which in the case of Figure 7 is quite good. From Figure 7 it can be interpreted that a storm with a return period of 100 years $H_{0.01}$ or $P(H_S)_{0.99}$ would produce a “significant wave height” of approximately 9.5 feet. The previous Coastal Situation Report (1988) reported a “significant wave height” of approximately 11.5 feet.

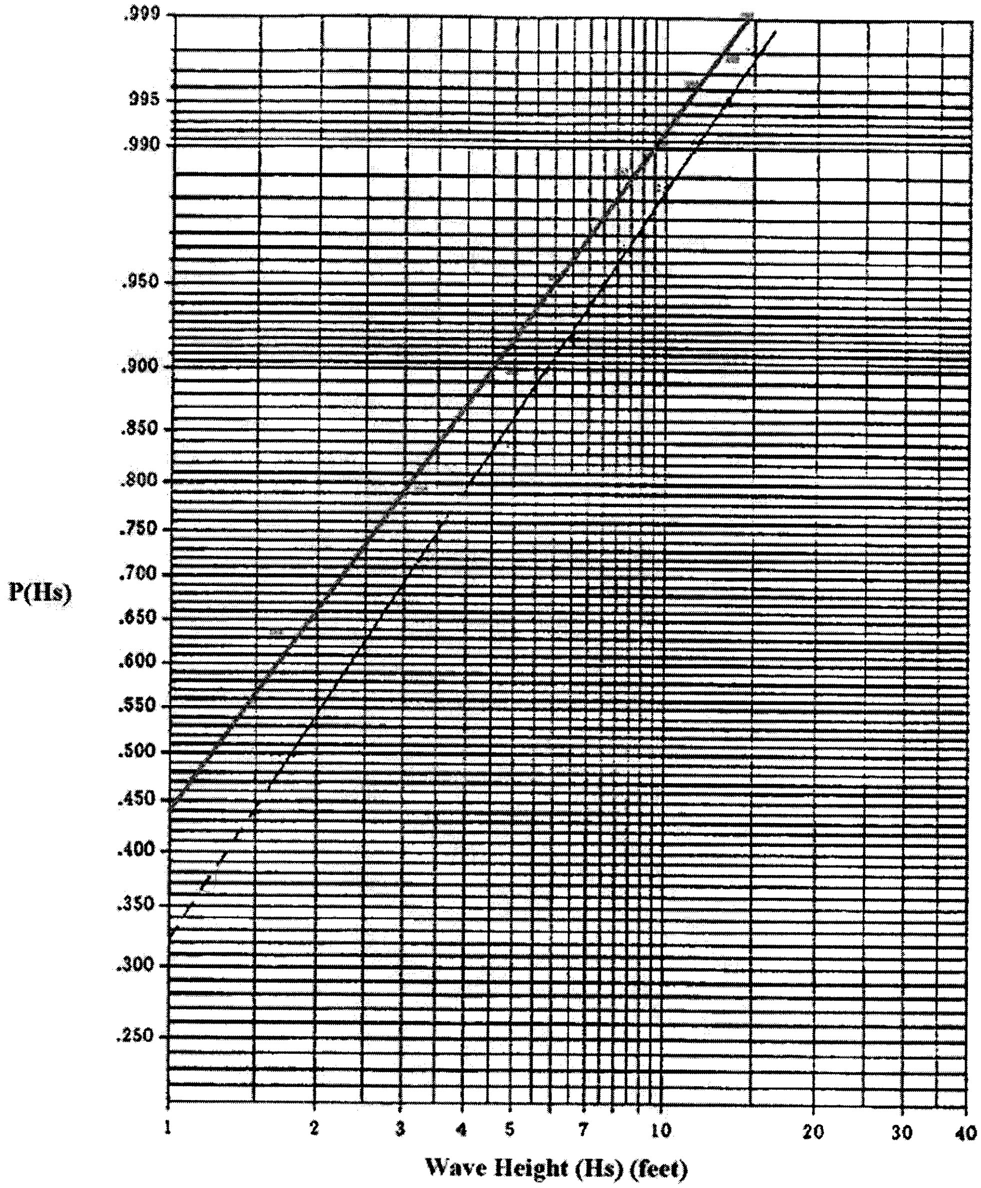


Figure 7: Wave Height Probability Distribution

The variation between the reported 1988 and 1998 “significant wave heights” is a result of a changing wave climatology. As depicted on Figure 7, the plot of the 1981 - 1995 data (thick line) resulted in a best fit line above the plot from the 1988 Coastal Situation Report. This change is a result of a higher percentage of waves being recorded at smaller heights for this study period. This indicates a statistically less intense wave climatology for the 1981 - 1995 period. As a result, the “significant wave height” was lower.

Wave height distributions on the Great Lakes and on the world's oceans appear to be well represented by a Rayleigh probability distribution. Table 4 gives the relation of wave height parameters to “significant wave height” for a cumulative Rayleigh probability distribution.

Parameter	Ratio
Significant height	1.00
Average height	0.64
Average of highest 10%	1.29
Average of highest 1%	1.68
Highest wave	1.87

Table 4: Relation of wave height parameters to “significant wave height”

A transformation of these ratios into a set of "real" wave heights for a storm with a return period of 100 years is shown in Table 5.

Parameter	Height in Feet
Significant height	9.50
Average height	6.08
Average of highest 10%	12.26
Average of highest 1%	15.96
Highest wave	17.77

Table 5: Height in feet of wave height parameters for a 100 year storm on Indiana's coastline

The calculated highest wave of 17.77 feet in the 1998 report is significantly lower than the calculated highest wave value, 21.5 feet, given in the 1988 Coastal Situation Report and the highest observed wave height of 22 feet recorded approximately a half mile offshore of Beverly Shores, Indiana by the Corps of Engineers in the 1970's. This is again the result of a higher percentage of smaller waves being recorded over the longer study period (1981 to 1995).

Storm Induced Sediment Movement at the Indiana Coast (Net Sediment Transport)

Erosion and subsequent sediment transport are episodic events that occur in response to the passage of storms at the coast. Figure 8 shows a representative "storm track" of a low pressure system across Lake Michigan. Also shown in this figure is the sequential development of waves and longshore currents on the

Indiana coast as the storm approaches and passes across the Lake Michigan. When the center of the storm is at position 1 over Minnesota, weak winds blow from the west. These weak winds generate small waves which create a weak longshore current. This weak longshore current moves a small volume of sediment along Indiana's coast from the west to east, which is opposite to the net sediment transport direction. As the storm moves across Lake Michigan to position 2 over Michigan, wind speeds begin to increase and shift to a more northerly direction. When the storm moves to position 3 over Canada, the strongest storm winds are now blowing from the north. These winds are able to transfer considerable energy into waves and generate large waves coming from the north because there is approximately 300 miles of open water (fetch) between the north end of Lake Michigan and the Indiana coast. These large waves generate strong longshore currents along the coast from east to west that move a large volume of sediment in the direction of the net sediment transport.

The net sediment transport is the direction that the largest volume of sand moves over a given period of time. If a small amount of sand moves east during the first part of a storm, but more sand moves west during the latter part of the same storm, the net direction of sand movement would be toward the west. If this pattern persists storm after storm, a net direction of sediment movement is established for that part of the coastline.

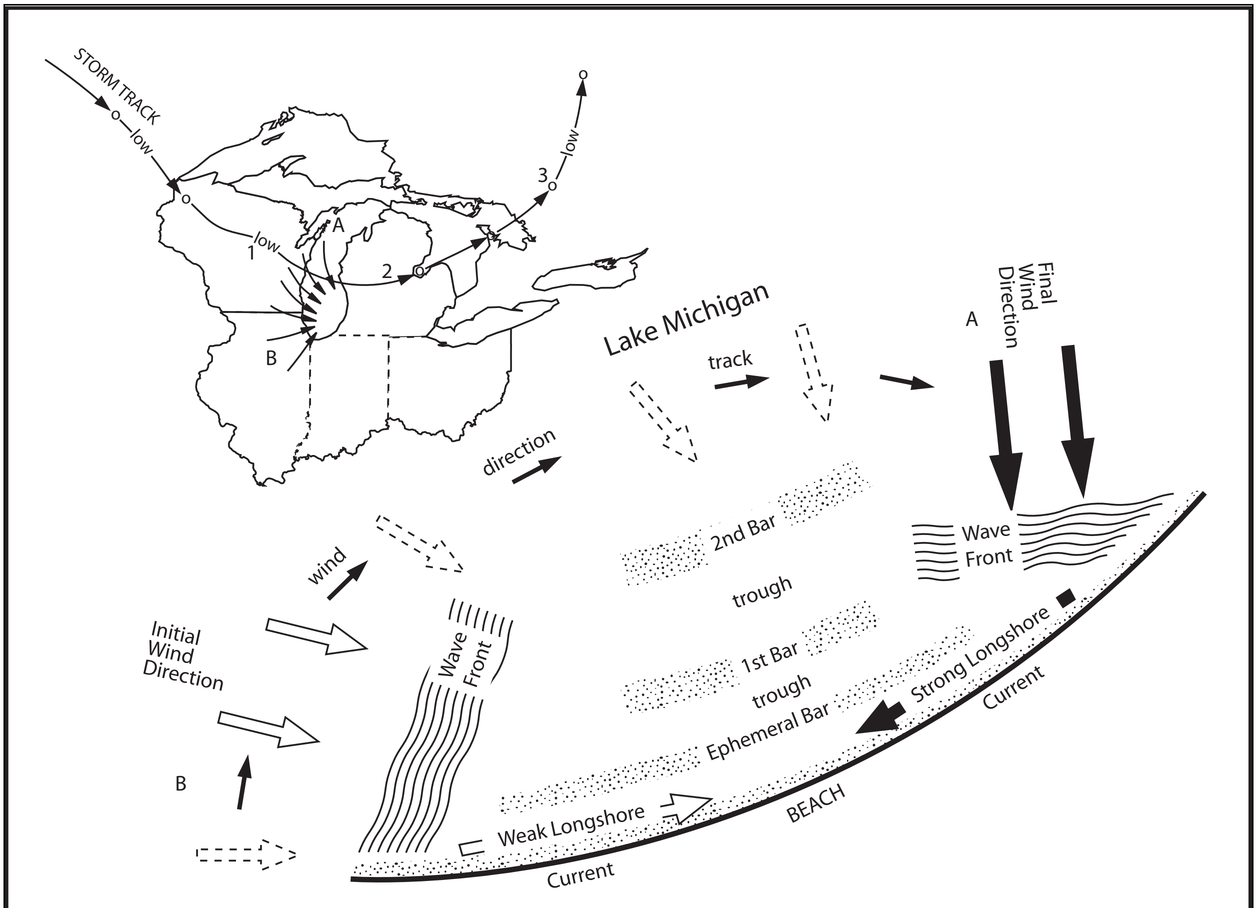
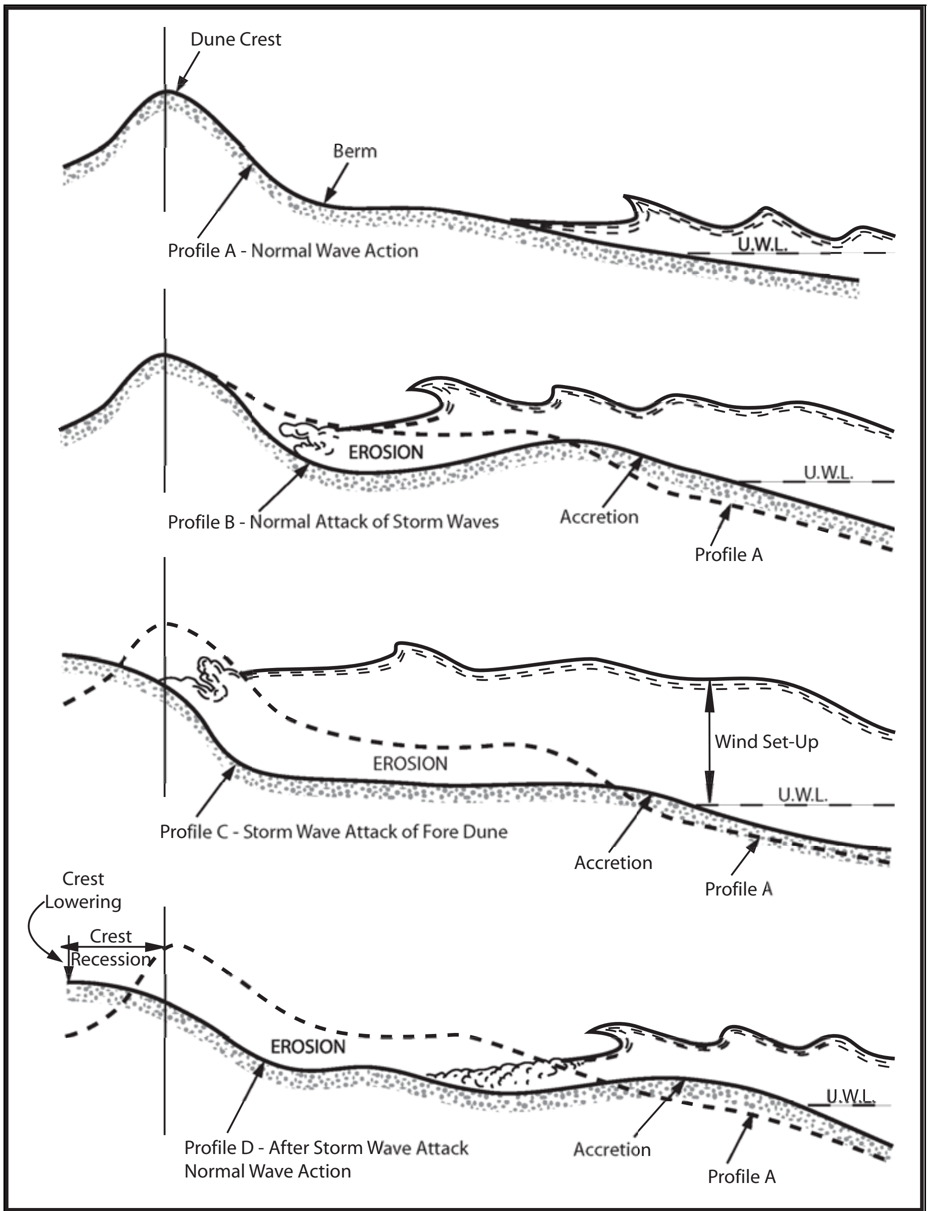


Figure 8: Storm Track and Resulting Waves and Currents

Wind Set-up

Another factor of importance in understanding the devastating impact of storms over the lake on the Indiana coast is wind set-up. Wind set-up is the increase in elevation of relative “still water level” due to wind stress actually "tilting" the lake surface. This effect is usually associated with strong northerly storms which tilt the lake surface resulting in lower water levels at the north end of the lake and higher water levels at the south end of the lake at the Indiana coast. Figure 9 shows a four diagram sequence depicting the increased erosion effect of wind set-up (profile C). Essentially, wind set-up raises the effective water level, which in turn allows the storm waves to penetrate further landward before breaking. This effect transfers more wave energy directly to the backbeach dune-bluff area resulting in high levels of coastal erosion and dune-bluff recession.



Schematic of wind set-up and resulting erosion.

Figure 9: Wind Set-Up and Erosion

Storm Rise Tables (US Army Corps of Engineers Lake Levels)
Storm rises occur as a result of high winds and changes in barometric pressure. The monthly storm induced rises are presented for the return periods, or recurrence intervals indicated in Table 6 for Calumet Harbor, Illinois. The monthly rises are based on an analysis of the maximum annual rise for each year which is the difference between the maximum and mean water level for a given month at a given gage location. The monthly rises are intended to be used in combination with the monthly mean lake levels provided in the Monthly Bulletin of Lake Levels for the Great Lakes. For example, at Calumet Harbor the probability that a 1.4 foot "storm induced rise" will be exceeded is 0.20 or 20 percent (Table 6). This represents a return period, or recurrence interval of once in 5 years for the month of May. If the May level for Lake Michigan is forecasted to be 580.0 feet, then there is a 20 percent (or 1 in 5) chance that a level of 581.4 feet will be equaled or exceeded at Calumet Harbor during the month of May.

	Probability of Exceedance				
	20%	10%	3%	2%	1%
January	1.6	1.8	2.1	2.3	2.5
February	1.5	1.8	2.0	2.2	2.4
March	1.6	1.8	2.2	2.5	2.8
April	1.5	1.7	2.0	2.2	2.3
May	1.4	1.7	2.0	2.2	2.5
June	1.3	1.5	1.8	1.9	2.1
July	1.1	1.4	1.9	2.3	2.7
August	1.2	1.4	1.6	1.8	2.0
September	1.3	1.6	1.9	2.2	2.5
October	1.3	1.6	2.1	2.4	2.8
November	1.5	1.7	2.0	2.2	2.4
December	1.6	1.9	2.3	2.6	2.8

Table 6: Lake Michigan at Calumet Harbor, Illinois. Possible Storm Induced Rises (in feet). Note: The rises shown above, should they occur, would be in addition to still water levels indicated on the Monthly Bulletin. Values of wave runup are not provided in this table.

The monthly "storm-induced rise" values do not represent the actual events of any particular storm and the associated maximum water level that occurs during the storm. This is because the "rises" are derived from the differences between the monthly maximum hourly or instantaneous event and mean water levels for the month (average of the daily levels) and not the instantaneous pre- or post-water levels measured from specific, or individual storms that occurred in the past.

Wave runup is the surge of water measured vertically from the still water level resulting from the wave acting on the shoreline structure, or beach. The runup is a function of wave height and structure type or shape and height. The wave height is a function of water depth, wind speed and direction, duration of the wind, and the offshore geometry. Large storm waves often break before reaching structures on the shoreline because the water depth is too shallow to support the wave.

COASTAL PROTECTION AND STRUCTURES

There are four general categories of coastal engineering problems that may require structural solutions: shoreline stabilization, backshore (dune-bluff) protection, inlet stabilization, and harbor protection (Shore Protection Manual, 1984). All four of these categories of coastal engineering problems are present on the Indiana shoreline. Factors that should be considered in evaluating each of these problem areas include: hydraulic characteristics, sedimentation, and control structure characteristics. Hydraulic considerations include: wind, waves, currents, storm surge or wind set-up, lake-level variation, and bathymetry. Sedimentation considerations include: sediment classification, distribution properties and characteristics; direction and rate of littoral transport; *net* versus *gross* littoral transport; and shoreline trend and alignment. Control structure considerations include selection of the protective works with respect to type, use, effectiveness, economics and environmental impact (Shore Protection Manual, 1984). It is important to note that a "no action" alternative should also be considered as a possible solution for any one of these categories of coastal problems.

Classification of Coastal Structures

Classification of coastal structures can be facilitated in various ways depending upon the criteria selected for classification. The 1998 report used the same method set forth by Wood and Davis (1986) that was used in the first Coastal Situation Report (1988). This method established a classification scheme based upon the degree of impact a structure imposes on the process/response system of the beach and nearshore zone. In other words, how much of this “breaking wave zone” width, where sand is normally transported along the shoreline by waves, is blocked by the structure. This classification scheme has three principal groups of structures referred to as primary, secondary and tertiary.

Primary Structures

Primary structures are large coastal constructions that form total or near total barriers to sediment transport parallel to the beach in the nearshore zone. This type of structure is represented by the Michigan City Harbor jetties, Port of Indiana/Bethlehem Steel Industrial Complex, the U.S. Steel/ Gary Harbor complex breakwalls, and the Indiana Harbor complex. Each of these structures extends lakeward across the littoral zone to a distance offshore where sediment transport becomes negligible. Their impact on downdrift shoreline is to increase erosion and subsequent dune-bluff recession by blocking sediment coming from the updrift direction that would normally supply the downdrift transport. Coastal engineers refer to these structures as "total sediment barriers."

A schematic representation of a primary structure is shown in Figure 10. Figure 10A shows the shoreline and nearshore bar configuration at the time of initial construction of the harbor jetties. Figure 10B depicts the shoreline and nearshore bar adjustment at some time in the future. As time progresses, the amount of shoreline loss on the downdrift side and gain on the updrift side will continue to increase. At the same time, sediment will be removed from the nearshore bars on the downdrift side of the harbor resulting in a gradual degradation of the protective bar system. The only natural way to mitigate primary structure impact on the downdrift shoreline is to replenish the material lost from the sediment transport system.

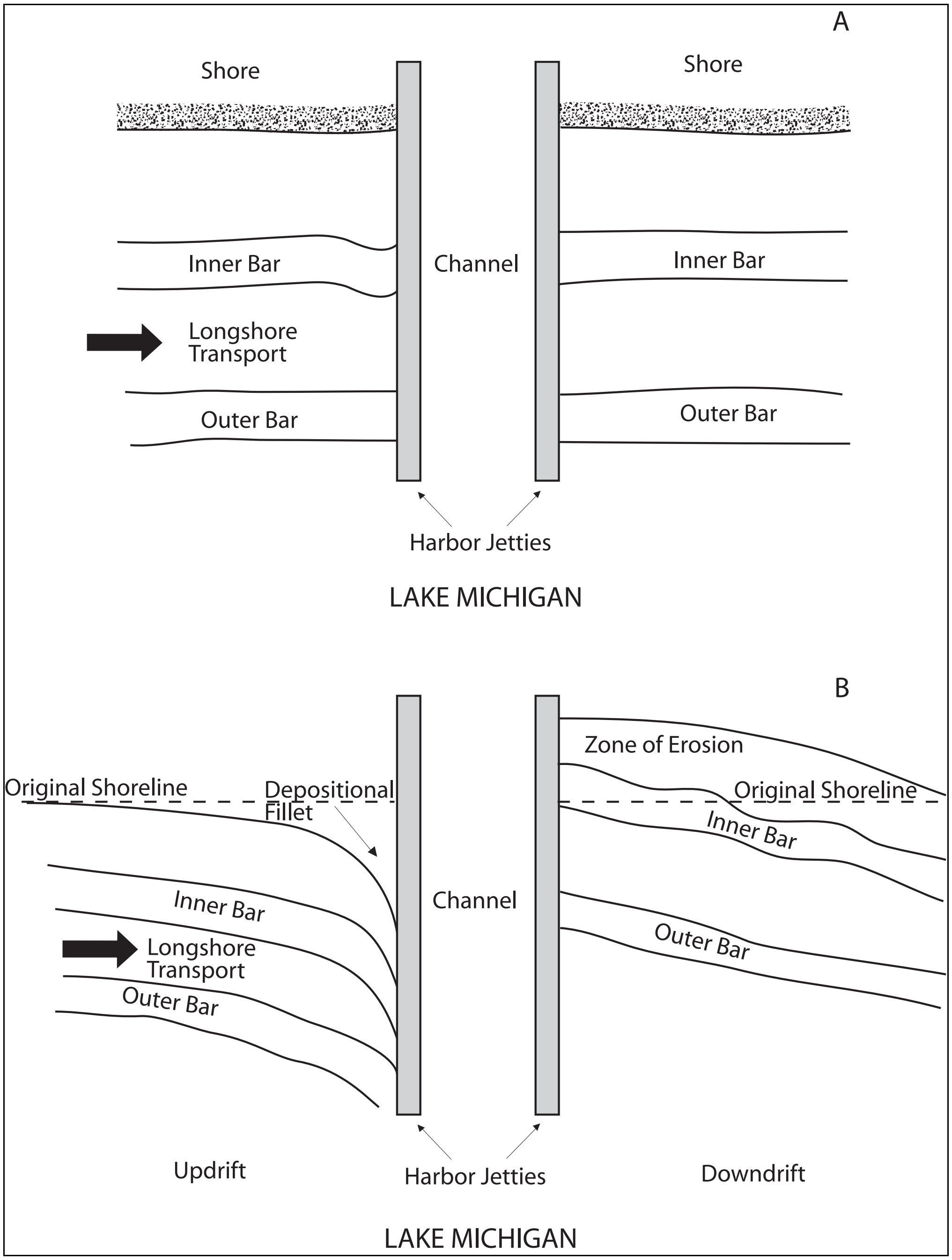


Figure 10A and 10B: Shoreline and Nearshore Response to Placement of Primary Structures

There are two engineering techniques generally recommended for replenishment of material lost from the transport system. Sand bypassing is a technique that mechanically transports material from the depositional fillet updrift to the zone of erosion downdrift (Figure 10B). Bypassing is accomplished by dredging material at the depositional fillet and either transporting it by barge or pumping it through pipes to the downdrift dump site. A major difficulty with barge or dredge transport in the Great Lakes is that these vessels are limited by water depth as to how close to shore they can dump material. Consequently, direct replenishment of the erosion zone is not possible in most locations. Pumping of the dredged material can be used for direct replenishment of the erosion zone, but this technique is usually limited by economic considerations related to the distance over which the slurry must travel. Beach nourishment is another technique that utilizes environmentally suitable material from either a lake or land source to rebuild the eroded beach zone. This technique is applicable to rebuilding any coastal beach region as well as rebuilding the zone of erosion downdrift from primary harbor structures. The major factor of concern in application of this technique is finding material that is suitable for both environmental and engineering design considerations.

Secondary Structures

Secondary structures are moderate sized structures that have significant impact on sediment transport, but do not form total sediment barriers. These structures generally affect between 25 and 75 percent of the net sediment transport in the nearshore zone. There are three types of secondary structures: shore-crossing, shore-parallel and combined.

Shore-crossing secondary structures protrude out into the nearshore zone to a distance greater than the inner-bar and less than or equal to the outer-bar positions. An example of this type of structure is the Burns Small Boat Harbor at the mouth of the Portage/Burns Waterway in Reach 3.

Shore-parallel secondary structures are relatively long (100's to 1000's of feet/ 10's to 100's of meters) engineering constructions that significantly influence net sediment transport. These structures can be located onshore, such as revetments and seawalls, or offshore such as detached or reef breakwaters. Examples of shore-parallel structures include the 13,000-foot long Beverly Shores rock revetment in Reach 1 and the combination “sheet steel and rock revetment” breakwater system at Porter Beach in Reach 2.

Combined secondary structures are those constructed with both shore-crossing and shore-parallel structures. The most common example of this type of structure is a series of shore-crossing groins protruding lakeward from a long rock revetment or conventional seawall system. Structures of this type are not presently exposed on the Indiana shoreline, although such a system was constructed in 1967 in front of NIPSCO Bailly Power Plant at the west end of Reach 2. This system is presently buried by sediment because it is updrift of a primary sand trapping structure (Port of Indiana/Bethlehem Steel Industrial Complex).

Mitigation of the erosion impact of secondary structures is, in most cases, an engineering irony. With the exception of small inlet jetties and some reef breakwaters, secondary structures are usually constructed to protect a specific segment of shoreline and stop erosion. The problem created is usually one of mitigating the erosion impact of an erosion control structure. One of the most frequently encountered engineering alternatives to mitigate secondary structure erosion is to extend the length of the structure in the downdrift direction. This alternative is not a solution, but merely a translation of the erosion problem to a new area of shoreline. In most cases of receding shoreline, construction of secondary "shore protection" structures signals the beginning of an endless sequence of building new erosion control structures.

Tertiary Structures

Tertiary structures are small-sized structures that have localized impact on sediment transport. These structures generally affect less than 10 percent of the net sediment transport in the littoral zone. These structures are typically breakwalls, short groins, longard tubes, sand bags, and debris piles built or placed on the shore to protect a single coastal residence. Since tertiary structures can be shore-crossing, shore-parallel or combined, their affect on the adjacent shoreline is similar to that of secondary structures. The main difference between secondary and tertiary structures is the distance downdrift and lakeward to which their effect is felt.

Tertiary structures have the greatest negative impact on the beach and fastland immediately downdrift from them. Figure 11 shows two groins built to protect home C. After construction of these tertiary structures, the shoreline adjusts as shown in Figure 11. Shoreline adjustment due to the sediment trapping not only results in protection of home C, but of homes B an A as well. Unfortunately, homes D and E are threatened by increased erosion immediately downdrift from the groins. Unless the owners of homes D and E build tertiary shore protection structures, they will lose their homes. Thus the same problem that arose with secondary structures arises again with tertiary structures. In fact, the sequential building of tertiary structures over linear shoreline distances of 100's to 1000's of feet (10's to 100's of meters) results in a secondary structure. Once again the "solution" to a shoreline erosion condition creates an erosion problem of greater magnitude.

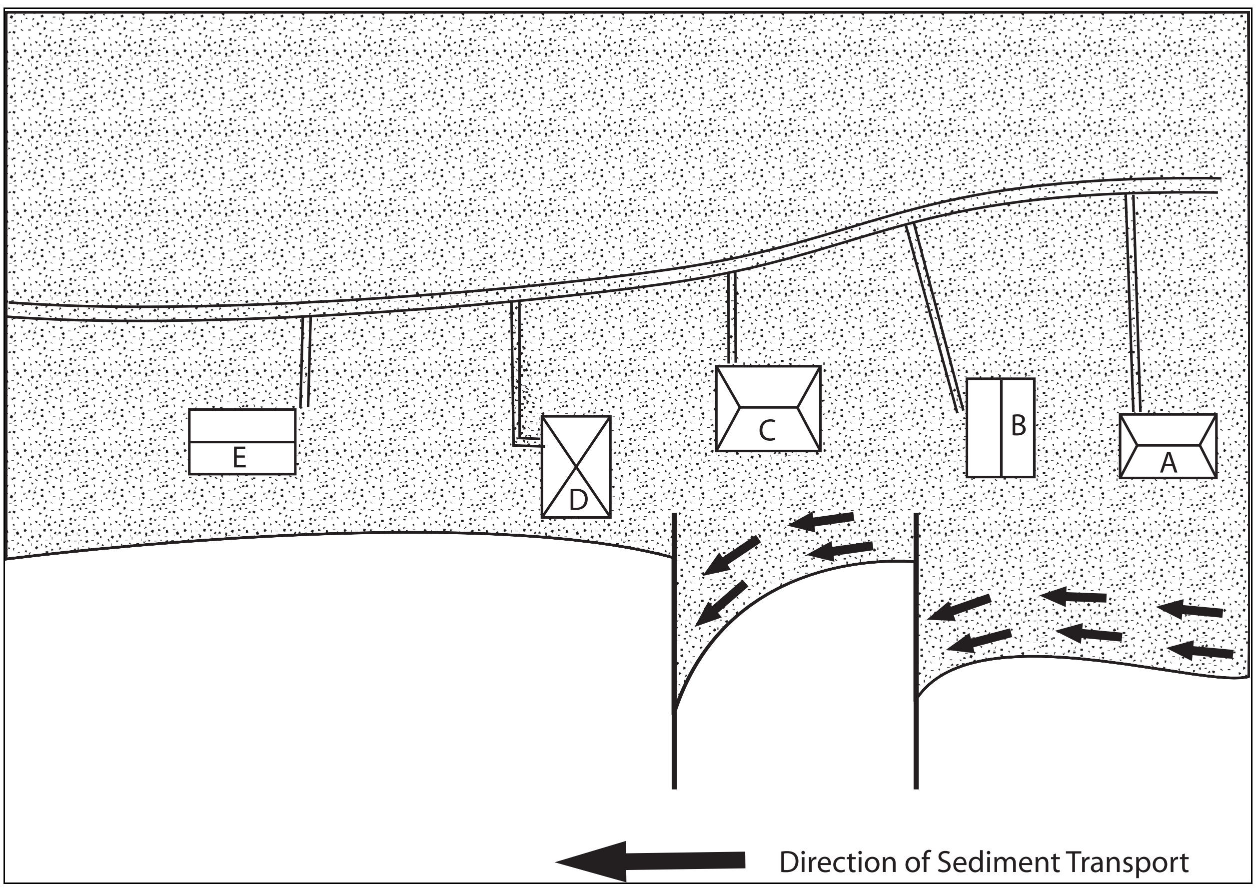


Figure 11: Groin Impact on Shoreline

Beach nourishment is a reasonable alternative to tertiary structure construction. However, effective beach nourishment projects are themselves considered secondary structures. The advantage of beach nourishment over constructing hard coastal structures is that erosion of the beach nourishment material actually supplies additional beach building sand to downdrift homeowners, instead of creating sand starved conditions resulting from building more hard seawalls. Implementation of beach nourishment requires large-scale cooperation and cost, which may not seem necessary to non-threatened downdrift homeowners. Consequently, construction of hard tertiary structures usually takes precedence over beach nourishment, and non-threatened homeowners soon find themselves threatened by the effects of downdrift erosion transfer.

Primary Structures on the Indiana Shoreline

Two of the four primary structures on the Indiana shore have created a shoreline situation similar to that shown in Figure 10B. The Michigan City Harbor jetties and breakwater complex is a total sediment barrier at the eastern end of Reach 1 that creates a zone of erosion from the Indiana Dunes National Lakeshore, Mt. Baldy recreation area, westward towards Beverly Shores. Sand bypassing is not an acceptable alternative at this site because of the adverse effect it would have on the large beach and recreation area of Washington Park. Even though this area accreted as the east (updrift) depositional fillet formed, its recreational benefits far exceed the needs for it as a sand bypass sediment source. However, there is a depositional fillet located behind the detached breakwater on the west (downdrift) side of the Michigan City Harbor that could become a source of sediment for bypassing westward. But, depending upon the quantities necessary to prevent further downdrift erosion, beach nourishment material from an offsite source is the best "natural" alternative for mitigating downdrift erosion created by the Michigan City Harbor structure.

The Port of Indiana/Bethlehem Steel Industrial complex is a total sediment barrier at the western end of Reach 2 and eastern end of Reach 3. This complex traps material at the western end of Reach 2, in front of the NIPSCO Bailly power station. It also creates a zone of erosion from Midwest Steel westward through Ogden Dunes in Reach 3. Sand bypassing is a potential engineering alternative at this primary structure because material in the depositional fillet area on the east (updrift) side of the Port of Indiana/Bethlehem Steel Industrial Complex could be dredged with no adverse impact on the adjacent beach area. However, the amount of material removed must be carefully engineered so as not to destabilize the updrift beach areas of Indiana Dunes National Lakeshore and western Dune Acres. Material removed from the east (updrift) fillet should be transported westward to the eastern end of Indiana Dunes National Lakeshore and Ogden Dunes coastline in Reach 3.

The U.S. Steel/Gary Harbor complex forms a littoral barrier at the west end of Reach 3. Significant amounts of sediment are deposited at the shore and in the nearshore zone. There is essentially no impact from this primary structure because: 1) the downdrift shoreline west of the structure (downdrift), where erosion would normally be expected, is totally armored for nearly 12 miles (19.32 km) to the west and 2) the orientation of the shoreline results in net sediment movement in the opposite direction from west to east.

The Indiana Harbor complex is the largest shore-crossing structure on the Indiana coast. It extends approximately 2 miles out into Lake Michigan and, therefore, is a total littoral barrier to the movement of sand in the eastward net sediment transport on this portion of Indiana’s coast in Reach 5. However, it has relatively little impact on the adjacent (downdrift) open coast of Reach 4. This is due to the limited amount of exposed beach in Reach 4, the wave sheltering effects that protect this area from the strongest northwest and north storm waves, and the wave diffraction effects provided by the Indiana Harbor complex itself. As expected, the complex does accumulate sediment on its west (updrift) side in Reach 5. However, there is relatively little sediment transported eastward towards this barrier that might otherwise enter Reach 4. The limited sediment transport from the west is due to the extensive breakwater structures extending out into Lake Michigan at Calumet Harbor, Illinois. It is doubtful that any significant amount of sediment is presently being transported southward from the Chicago and south Chicago coast. It is also because of this limited sediment supply that the impact of the Hammond Marina structure, in Reach 5, upon adjacent shoreline will be of little significance in comparison to the blocking effects of Calumet Harbor, Illinois and Indiana Harbor.

Impact of Primary Structures

The following presents a brief history and analysis of each of the primary coastal structures along Indiana's coastline. Each section includes a brief history of the structure and sediment transport rates at the structure. Sediment transport rates were calculated using a sediment transport model for each primary structure location using a "deep water" wave height and angle. Three directions of wave approach angle were selected for the wave refraction analysis, 0^O, 30^O and -30^O.

Sediment Transport at Michigan City

Results of sediment transport rate calculations at Michigan City are summarized in Table 7. The sediment transport rates shown in Table 7 are calculated for nine months of ice-free lake conditions. The calculated net sediment transport volume is approximately 128,300 yds^3/yr to the west. This value compares favorably with previous estimates by the U.S. Army Corps of Engineers of 90,000 yds^3/yr (1975) and 115,000 yds^3/yr (1982), and by the Great Lakes Coastal Research Laboratory of 88,000 yds^3/yr (1988). This calculated net westward transport is consistent with the historic shoreline changes observed at Michigan City. It also implies that a significant quantity of material is trapped on the east (updrift) side of the jetty and diverted by the harbor complex, resulting in severe downdrift erosion on the west side of the Michigan City complex observed in the eastern portion of Reach 1 at Mt. Baldy.

Sediment Transport at the Port of Indiana/Bethlehem Steel Industrial Complex

Results of sediment transport rate calculations at Port of Indiana/Bethlehem Steel Industrial Complex are summarized in Table 8. The sediment transport rates shown in Table 8 are calculated for nine months of ice-free lake conditions. The calculated net sediment transport volume is approximately 43,000 yds^3/yr to the west. This value is high when compared with previous aerial photographic estimates of 17,000 yds^3/yr (Wood and Davis, 1986) and lower than the previously computed rate by the Great Lakes Coastal Research Laboratory of 75,500 yds^3/yr (1988). The U.S. Army Corp of Engineers (1982) estimated that approximately 27,000 yds^3 of sediment are transported westward at the location of the Port of Indiana/Bethlehem Steel Industrial Complex. This apparent difference in computed versus observed sediment transport rate is related to the assumed "window" of wave direction approach applied to the computational grid. What is important is that large volumes of sediment are transported along the coast at the Port of Indiana/Bethlehem Steel Industrial Complex, resulting in significant sand accumulation on the east side of the Port of Indiana/Bethlehem Steel Industrial Complex (at NIPSCO Bailly power plant) and significant downdrift (west) erosion in the eastern portion of Reach 3 at Ogden Dunes.

Sediment Transport at U.S. Steel/Gary Harbor

Results of sediment transport rate calculations at U.S. Steel/Gary Harbor are summarized in Table 9. The sediment transport rates shown in Table 9 are calculated for nine months of ice-free lake conditions. The calculated net sediment transport volume is approximately 39,200 yds^3/yr to the east. This value compares well to that of the U.S. Army Corp of Engineers (1978) estimate of 40,000 yds^3/yr for western Reach 3. These values are much lower than the previously computed rate by the Great Lakes Coastal Research Laboratory of 156,000 yds^3/yr (1988). The difference in computed values stems from the various shoreline orientations chosen. The 1988 value was computed with a shoreline orientation of 90^O, and the new value as well as the 1978 value had a shoreline orientation of 86^O. An important point is interpreting the calculated sediment transport rates shown in Table 9 is sediment availability. The shoreline for more than 10 miles to the west of Gary Harbor is armored and fronted by relatively deep water resulting in a limited supply of sediment available for transport on this section of coast. The limited sediment availability may explain the seeming paradox between the eastward transport rate calculated by the model, even though there is an observed actual westward transport resulting in deposition of sediments against the U.S. Steel breakwall.

Sediment Transport at Indiana Harbor Complex

Sediment transport calculations were carried out for the length of shoreline occupied by the Indiana Harbor complex in Lake County. The meaningfulness of this calculation is doubtful owing to the lack of sediment supply and the highly complex nature of the bathymetry and engineered shoreline. Therefore, a table of calculated transport volumes is not presented, to avoid misinterpretation of these values.

One of the most significant shoreline effects of the Indiana Harbor complex is the reversed trend in net sediment transport produced on the east side of the complex (Reach 4). Sand accumulates on the west side, as expected, due to the north and northwest storm waves which create a predominate westward movement of sediment along this length of Indiana shoreline. However, sand also accumulates on the east side of the complex in Reach 5, where one would normally expect to see erosion. The reason for this reversal is the immense size of the Indiana Harbor complex, which prevents waves from the north and northwest from directly reaching this length of coastline. This sheltering effect results in the east waves dominating the net movement of sand in this area (Reach 4), pushing sediment toward the west. The U.S. Army Corps of Engineers (1978) calculated a longshore transport of 8,600 yds^3/yr to the northwest for this stretch of coastline.

Secondary and Tertiary Structures on the Indiana Shoreline

The impact of secondary structures is highly specific to the type, location and lifetime of the structure. Likewise, tertiary structures have highly localized effects on erosion and shoreline adjustment. Therefore, the effects of both types of structures will be discussed in the section on Coastal Stability for the individual reaches of shoreline.

Direction	-82.5	-75	-55	-35	-15	-2.5	5	25	45	65	82.5
Wave Height (m)											
0.125	-8.997	-59.936	-121.017	-121.966	-76.216	-5.704	34.071	696.541	450.488	131.836	18.454
0.50	-204.115	-1523.042	-3036.582	-2901.725	-1982.993	-110.217	658.314	9854.884	11654.213	2974.091	436.747
1.00	-306.186	-2654.115	-6199.204	-7312.973	-5198.113	-258.586	1544.508	17400.196	23378.204	5166.487	812.710
1.50	-328.688	-3624.427	-8602.627	-12337.108	-8944.003	-400.051	2389.463	23827.906	27075.535	5462.207	861.247
2.00	-283.350	-3027.328	-8526.973	-10755.636	-8084.114	-426.616	2548.131	26178.262	26784.856	5077.884	499.113
2.50	-154.552	-3070.618	-7853.531	-7795.897	-7441.439	-514.587	3073.572	17161.226	20852.136	3136.252	206.070
3.00	-91.259	-1852.975	-4111.910	-7791.463	-5400.178	-284.784	1700.9866	10898.855	13832.558	1863.384	19.556
3.50	-74.578	-427.413	-784.065	-3214.228	-4277.272	-193.194	1153.926	8778.645	12748.461	148.047	0.000
4.00	-38.241	-467.554	0.000	-879.024	-1462.181	-99.957	597.033	6614.383	5710.544	0.000	0.000
4.50	-16.834	-617.438	-353.955	-2708.566	-1287.286	-37.714	225.265	6146.684	4365.945	267.335	0.000
5.00	0.000	0.000	-1363.746	0.000	0.000	0.000	0.000	8309.626	4587.672	0.000	0.000
5.50	0.000	0.000	0.000	0.000	0.000	-15.201	90.796	1564.747	0.000	0.000	0.000
Total (m^3/year)	-1506.802	-17324.846	-40953.611	-55818.587	-44153.784	-2346.611	14016.064	137431.954	151440.612	24227.522	2853.895
Total (yds^3/year)	-1152.033	-13245.795	-31311.282	-42676.372	-33757.991	-1794.113	10716.050	105074.268	115784.656	18523.270	2181.959

	$Q_{eastward}$	$Q_{westward}$	Q_{net}	Q_{gross}
m^3/year	-162104.240	329970.047	167865.807	492074.287
yds^3/year	-123937.584	252280.203	128342.618	376217.787

Table 7: Quantity of sediment transport for the Michigan City Area. Note: Negative sign indicates transport from west to east. Direction is perpendicular from true North (0^o).

Direction	-85	-70	-50	-30	-10	10	30	50	70	85
Wave Height (m)										
0.125	-8.030	-73.679	-121.852	-130.109	-90.367	321.600	415.698	190.640	78.747	8.096
0.50	-204.061	-1848.779	-2899.018	-3385.179	-1746.057	4550.105	10754.203	4300.657	1863.723	211.437
1.00	-355.605	-3774.296	-7306.150	-8873.731	-4096.524	8033.856	21572.796	7470.950	3468.065	371.034
1.50	-485.610	-5237.586	-12325.598	-15268.364	-6337.610	11001.598	24984.596	7898.575	3675.187	347.595
2.00	-405.609	-5191.524	-10745.601	-13800.442	-6758.449	12086.783	24716.365	7342.827	2129.856	252.308
2.50	-411.409	-4781.509	-7788.624	-12703.328	-8152.084	7923.521	19241.806	4535.148	879.358	126.587
3.00	-248.266	-2503.477	-7784.194	-9218.678	-4511.554	5032.118	12764.323	2694.529	83.449	56.060
3.50	-57.266	-477.367	-3211.230	-7301.760	-3060.575	4053.194	11763.946	214.082	0.000	0.000
4.00	-62.644	0.000	-878.204	-2496.098	-1583.520	3053.931	5269.541	0.000	0.000	0.000
4.50	-82.726	-215.500	-2706.039	-2197.517	-597.471	2837.989	4028.780	386.577	267.335	0.000
5.00	0.000	-830.297	0.000	0.000	0.000	2836.643	4233.384	0.000	0.000	0.000
5.50	0.000	0.000	0.000	0.000	-240.820	722.460	0.000	0.000	0.000	0.000
Total (m^3/year)	-2313.198	-24934.015	-55766.511	-75375.207	-37175.030	63453.798	139745.439	35033.985	12178.386	1373.118
Total (yds^3/year)	-1768.566	-19063.423	-42636.557	-57628.481	-28422.350	48513.910	106843.054	26785.404	9311.044	10493824

	$Q_{eastward}$	$Q_{westward}$	Q_{net}	Q_{gross}
m^3/year	-195563.961	251784.726	56220.766	447348.687
yds^3/year	-149519.376	192503.236	42983.860	342022.612

Table 8: Quantity of sediment transport for the Port of Indiana/Bethlehem Steel Industrial Complex. Note: Negative sign indicates transport from west to east. Direction is perpendicular from true North (0^o).

Direction	-81	-61	-41	-21	-5.5	4.5	19	39	59	79	89.5
Wave Height (m)											
0.125	-25.884	-98.052	-144.135	-174.923	-99.212	66.575	302.902	199.092	120.150	42.606	0.053
0.50	-649.481	-2332.779	-3750.108	-3379.833	-1403.687	941.931	7836.138	4491.322	2843.632	1112.677	1.231
1.00	-1325.921	-5879.104	-9830.336	-7929.620	-2478.407	1663.113	15719.194	7802.166	5291.505	1952.553	2.074
1.50	-1839.797	-9918.148	-16914.322	-12267.679	-3393.942	2277.475	18205.230	8248.749	5607.528	1829.202	1.304
2.00	-1823.797	-8646.758	-15288.155	-13082.296	-3728.716	2502.122	18009.782	7668.363	3249.692	1327.760	1.448
2.50	-1679.758	-6267.341	-14072.771	-15779.948	-2444.369	1640.273	14020.699	4736.209	1341.707	666.161	0.478
3.00	-879.479	-6263.777	-10212.468	-8732.992	-1552.385	1041.714	9300.828	2813.988	127.325	295.014	0.499
3.50	-167.700	-2584.009	-8088.903	-5924.340	-1250.391	839.064	8571.896	223.573	0.000	0.000	0.260
4.00	0.000	-706.672	-2765.183	-3065.413	-942.124	632.204	3839.694	0.000	0.000	0.000	0.266
4.50	-75.706	-2177.492	-2434.413	-1156.522	-875.507	587.501	2935.604	403.715	0.000	0.000	0.000
5.00	-291.686	0.000	0.000	0.000	-1183.587	794.236	3084.690	0.000	0.000	0.000	0.000
5.50	0.000	0.000	0.000	-466.154	-222.876	149.559	0.000	0.000	0.000	0.000	0.000
Total (m^3/year)	-8759.391	-44874.133	-83500.795	-71959.518	-19575.202	13135.768	101826.657	36587.176	18581.540	7225.973	7.614
Total (yds^3/year)	-6697.035	-34308.736	-63840.938	-55016.999	-14966.315	10043.015	77852.066	27972.903	14206.607	5524.653	5.822

	$Q_{eastward}$	$Q_{westward}$	Q_{net}	Q_{gross}
m^3/year	-215533.270	164228.961	-51304.304	379762.231
yds^3/year	-164787.009	125562.050	-39224.959	290349.059

Table 9: Quantity of sediment transport for the U.S. Steel/Gary Harbor Area. Note: Negative sign indicates transport from west to east. Direction is degrees from perpendicular to true North (0^o).

SHORELINE CHANGE OVER TIME

Aerial photographs dating from 1939 to 1987 were available at the Great Lakes Coastal Research Lab (GLCRL) at Purdue University and were used to determine shoreline change based on bluff position, beach condition, water edge movement, and man-made structure performance. Beach and nearshore profile data collected annually at 43 positions on the Indiana shoreline from 1968 to 1973 by the U.S. Army Corps of Engineers, Coastal Engineering Research Center (CERC) were also available on GLCRL's computerized lakeshore database system. In addition, GLCRL's extensive survey data of beach and nearshore profiles collected at numerous locations from 1974 to 1986, were also available on the computerized lakeshore database system. The 1998 study has expanded the aerial photographs database to include photos from 1987 to 1995.

The nearshore region, extending from –20 feet of water depth to water's edge, is characterized by the presence of one or two permanent longshore sand bars that migrate onshore and offshore in response to lake-level fluctuation and wind-wave action. Most of the active sediment transport (movement of sand by waves and currents) occurs in the nearshore region. Sediment transport within this region usually occurs on a time scale from a few hours to a few days depending on the frequency and duration of local storms. The width of the nearshore region and the number of sand bars present within it are extremely important factors for assessing coastal erosion. Wide, multiple barred nearshore regions dissipate large amounts of incoming wave energy while a narrow, unbarred region offers very little resistance to incoming waves.

In the region lying at water depths greater than -15 to -20 feet (MSWL), which will be referred to as the offshore region, sediment accumulation and depletion occurs on a much longer time scale (annually or longer).

Coastal Erosion and Recession

A major part of shoreline change is erosion and recession over time. In the 1998 report, erosion is defined as a loss of material from a cross-sectional area of beach or dune. Recession is defined as the retreat of a specific point on a cross-section of the beach or dune with no necessary loss of material. Stated in more generalized terms, erosion is related to the net loss of material, while recession is related to topographic changes with no necessary net loss of material.

There are three specific points on a beach-dune profile which are normally referenced when evaluating recession rates: 1) shoreline (0 feet MSWL), 2) toe of dune-bluff, and 3) top of dune-bluff. Of these three, shoreline is the most ambiguous reference point for determining recession rates. For example, the annual lake-level cycle produces a recession and advance of the shoreline regardless of the occurrence of any actual erosion and/or deposition.

The use of "toe of dune-bluff" or "top of dune-bluff" measurements to determine recession and erosion rates provide a degree of improvement over shoreline, but these measurements are also difficult to interpret directly. Figure 12 shows the various toe and top of dune-bluff (summit) changes that can be anticipated for a coastal dune foreslope. This series of diagrams illustrates the complex nature of foreslope variability and supports the argument that recession rates cannot be directly interpreted as erosion rates. However, of these two, the "top of dune-bluff" provides the best estimate of erosion on the coast.

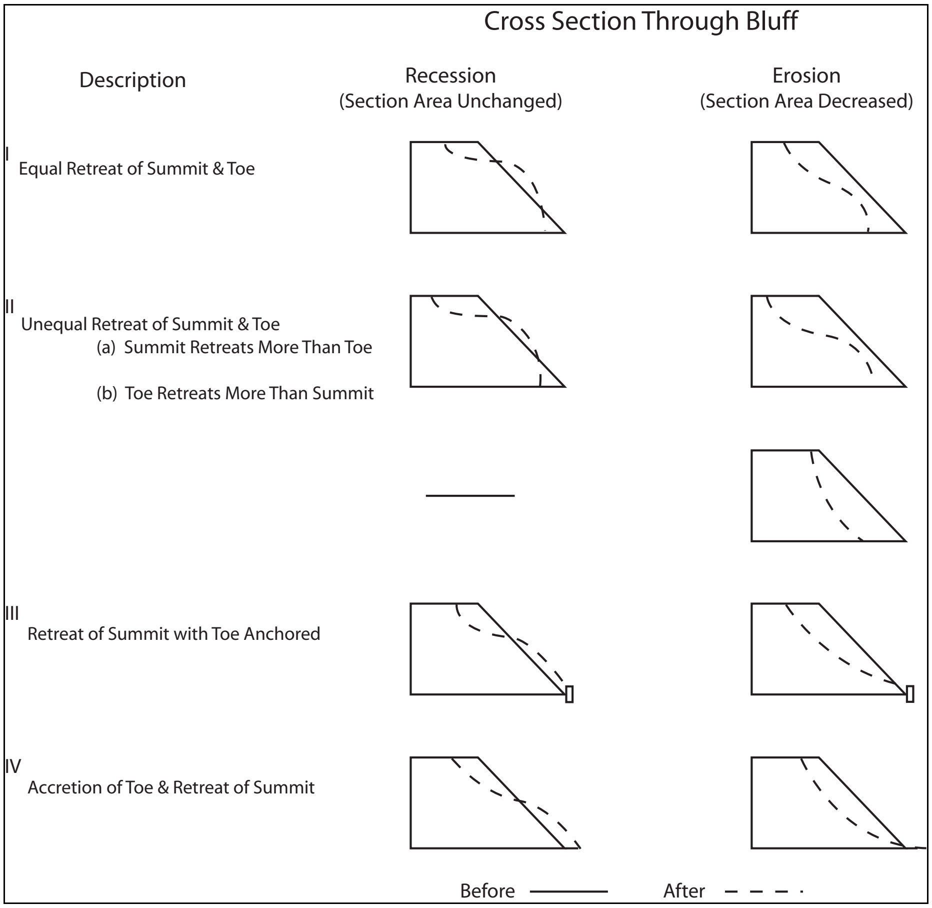


Figure 12: Difference between Recession (no loss of material) & Erosion (loss of material)

COASTAL STABILITY EVALUATION

The intent of this section is to provide a unified, updated (1995) evaluation of shoreline change along Indiana's coast. There are maps illustrating each length of coastline within the individual littoral cells (reaches) except in areas where dune-bluff is poorly defined. Below the maps are figures, graphs, and tables that show cumulative dune-bluff recession/accretion. Figures of the cumulative water's edge movement are not presented due to the subjectivity of interpreting this data, as discussed below.

The position of the water's edge can vary on a daily or even hourly basis subject to a number of phenomena including erosion, wind and wave setup, and pressure setup. Therefore, it would be necessary to account for each of these temporary occurrences and variations in order to evaluate the observed movement of the water's edge. However, the movement of the top of the dune-bluff is directly dependent upon erosion, and therefore is a much better indicator of shoreline erosion than is movement of the water's edge.

Figure 13 depicts spatial shoreline changes associated with lake-level rise. Shoreline retreat is shown in Figure 13 to be a combination of encroachment (apparent loss of beach due to submergence under water) and recession (real loss of beach material due to erosion of the dune-bluff, which results in the depicted profile adjustment). Of these two losses, recession is less likely to be restored under conditions of falling lake-level because the dune bluff material that was lost would need to be replaced. Encroachment is totally recoverable because the falling lake level re-exposes the previously submerged beach. This section provides recession/accretion data at specific points on the coastline (referred to as recession).

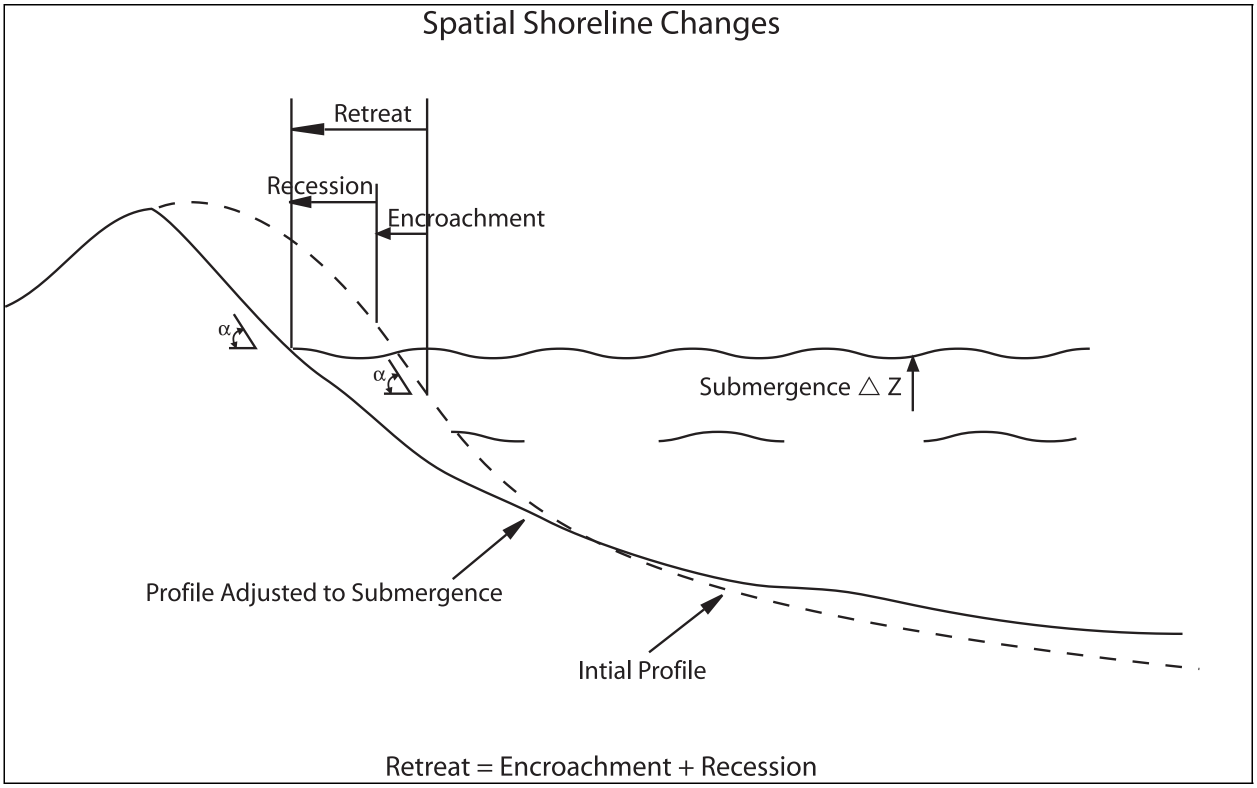


Figure 13: Definition Diagram Depicting Three Concepts of Spatial Shoreline Change: Retreat, Encroachment and Recession

The data in this section were compiled primarily from aerial photographs and were verified at specific locations with beach survey data collected by GLCRL beginning in 1975. The maps in four of the five sections are drawn for the time period 1976-78 (dependent upon aerial photography and ground truth availability) to 1995. The figure for the littoral cell for Reaches 1 and 2 was drawn for the time period 1969 to 1995 because ground verification existed and because more detail could be provided on the Indiana Dunes State Park area within this cell.

Historical recession rates are given in detailed tables for each numbered position shown on the maps. Where aerial photographs were available, these rates are calculated as far back as 1938.

The seventy-seven (77) locations used for recession measurements are shown in a series of five detailed maps. These locations were selected to correspond to well established beach survey lines, important coastal features (i.e., updrift from structural traps), or easily recognizable landmarks (roads, buildings, or coastal structures).

MAP Index and Aerial Photo (AP) Positions

Reach 5 Hammond, Whiting, BP (Amoco)
Map 1 AP 1-22 Table 10

Pastrick Marina – Gary Works Harbor (east)
Map 2 AP 23-32 Table 11

US Steel (west) – Ogden Dunes
Map 3 AP 33-45 Table 12

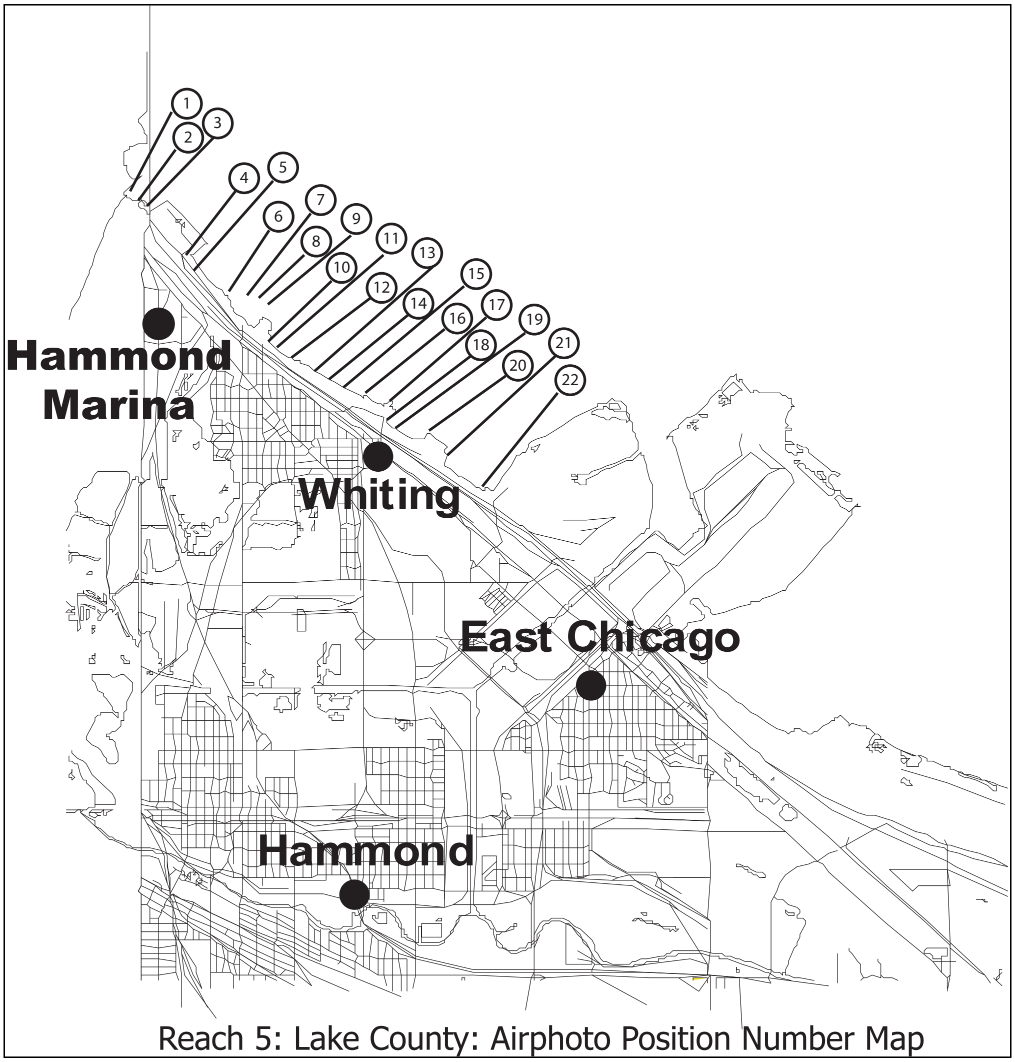
Bethlehem Steel – Michigan City
Map 4 AP 46-65 Table 13

Michigan City – Michigan State Line
Map 5 AP 66-77 Table 14

Coastal Stability, Reach 5

This reach evaluation presents detailed recession measurements for 22 locations from the Illinois-Indiana state line to Indiana Harbor shown on Map 1. Locations 3 to 18 are within the area designated as Reach 5 (Figure 2). Table 10 lists cumulative dune-bluff recession and annual recession rates for those locations with a dune-bluff present. Data are shown for the 57-year period from 1938 to 1995.

In summary, this area remained relatively stable over the eight-year study period (1987-1995) as was the case in previous years. Dune-bluff recession was found to be relatively consistent at the three measured positions ranging from a gain of 15.4 feet to 17.2 feet. None of these areas showed signs of long-term erosion over the period from 1987 to 1995. One notable exception to the area's stability was observed at position 14 between 1987 and 1990. During this time period, 6.4 feet of erosion was recorded. This could have been a result of excessive storm wave attack during this span of time from a direction that resulted in erosion. This lost material was subsequently replaced over the next 5 years. A detailed discussion of beach and offshore profiles for Reach 5 is presented in the Hammond Marina Site Evaluation Report (1987).



Map 1: Location Map, Reach 5

[NOTE: A graph showing the cumulative dune-bluff erosion curve in Reach 5 was not drafted because of the limited number of data points (5) that were applicable.]

AIRPHOTO	1938 - 1955		1955 - 1976		1976 - 1987		1987 - 1995			No. of
POSITION	Recession	Rate	Recession	Rate	Recession	Rate	Recession	Rate	Total	Years
NUMBER	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	
1	---	---	---	---	---	---	---	---	---	
2	---	---	---	---	---	---	---	---	---	
3	---	---	---	---	---	---	---	---	---	
4	---	---	---	---	---	---	---	---	---	
5	73.5	4.30	50.0	2.40	-8.0	-0.70	17.2	2.15	132.7	(57)
6	---	---	-21.4	-1.00	12.0	1.10	15.4	1.93	6.0	(40)
7	3.4	0.20	10.5	0.50	-20.0	-1.80	---	---	---	(49)

AIRPHOTO	1938 - 1955		1955 - 1976		1976 - 1987		1987 - 1995			No. of
POSITION	Recession	Rate	Recession	Rate	Recession	Rate	Recession	Rate	Total	Years
NUMBER	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	
8	---	---	---	---	---	---	---	---	---	
9	---	---	---	---	---	---	---	---	---	
10	---	---	---	---	---	---	---	---	---	
11	---	---	---	---	---	---	---	---	---	
12	-82.7	-4.90	---	---	---	---	---	---	-82.7	(17)
13	---	---	-7.7	-0.40	-15.0	-1.40	---	---	-22.7	(40)
14	7.4	0.40	15.0	0.70	4.0	0.40	16.6	2.08	43.0	(57)
15	---	---	---	---	---	---	---	---	---	
16	---	---	---	---	---	---	---	---	---	
17	---	---	---	---	---	---	---	---	---	
18	---	---	---	---	---	---	---	---	---	
19	---	---	---	---	---	---	---	---	---	
20	---	---	---	---	---	---	---	---	---	
21	-5.3	-0.30	3.8	0.20	---	---	---	---	-1.5	(46)
22	---	---	---	---	---	---	---		---	

Table 10: Cumulative Dune-Bluff Recession and Annual Recession Rates, Reach 5

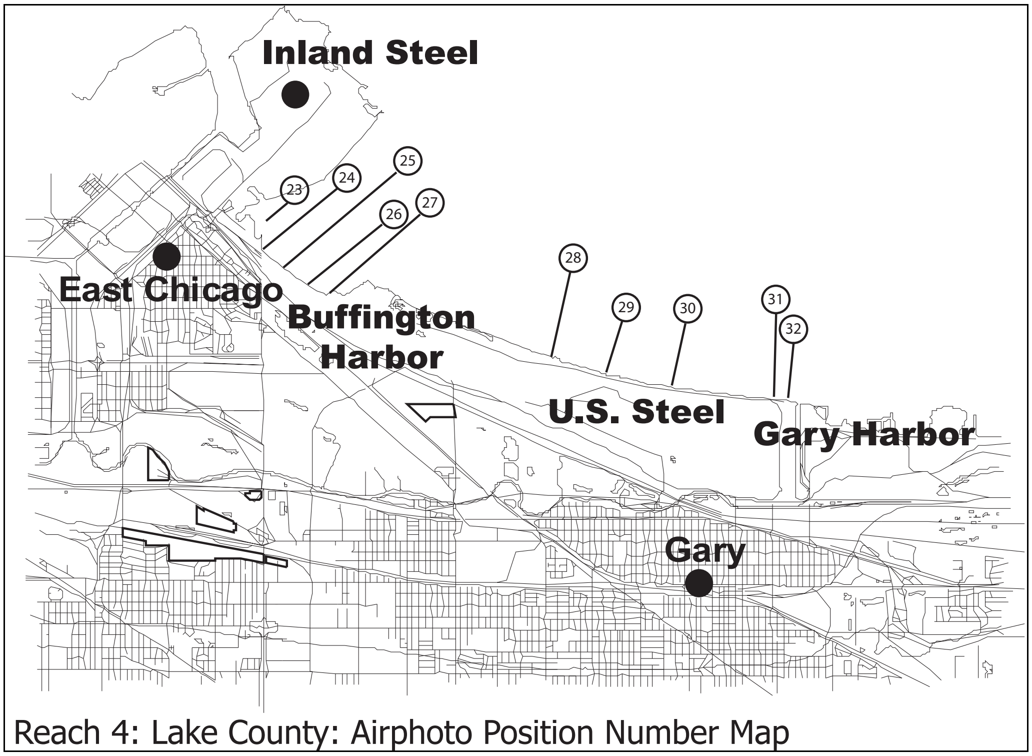
Last Updated on 10/17/98 By Computing Center

Coastal Stability Reach 4

This reach evaluation presents detailed recession measurements for 10 locations from Indiana Harbor to Gary Harbor as shown on Map 2. Locations 23 to 27 are within the area designated as Reach 4 (Figure 2). Table 11 lists cumulative dune-bluff recession and annual recession rates for the 57 year period from 1938 to 1995. Figure 14 shows cumulative dune-bluff recession for the period 1987 to 1995.

This area has been highly engineered and is protected from all, but northeasterly, storm waves by the Indiana Harbor complex. This situation has greatly reduced dune-bluff recession within Reach 4. The artificial nature of this shoreline makes it difficult to interpret any of the data in a contemporary framework. What is evident in Table 11 is the high rates of dune-bluff recession prior to armoring of most of this coastal reach. Locations 26 to 30 all show substantial loss from 1938 to 1955 and 1955 to 1976. Erosion was observed at three locations in this study area. Two of the three positions occurred in historically erosional areas (28) or downdrift of a sediment trapping structure (31). Significant loss of material (24 feet) was noted downdrift (west) of Gary Harbor due to this structure eliminating westward migration of sediment. An exception to this was found at location 32 where rock revetment and rubble protects the shoreline.

There is additional beach and offshore profile data for locations 23-27 from 1997 to 2001. This data was collected during a 5-year monitoring program conducted at Pastrick Marina as a condition of the State permit for construction of the new gaming boat breakwater.



Map 2: Location Map, Reach 4

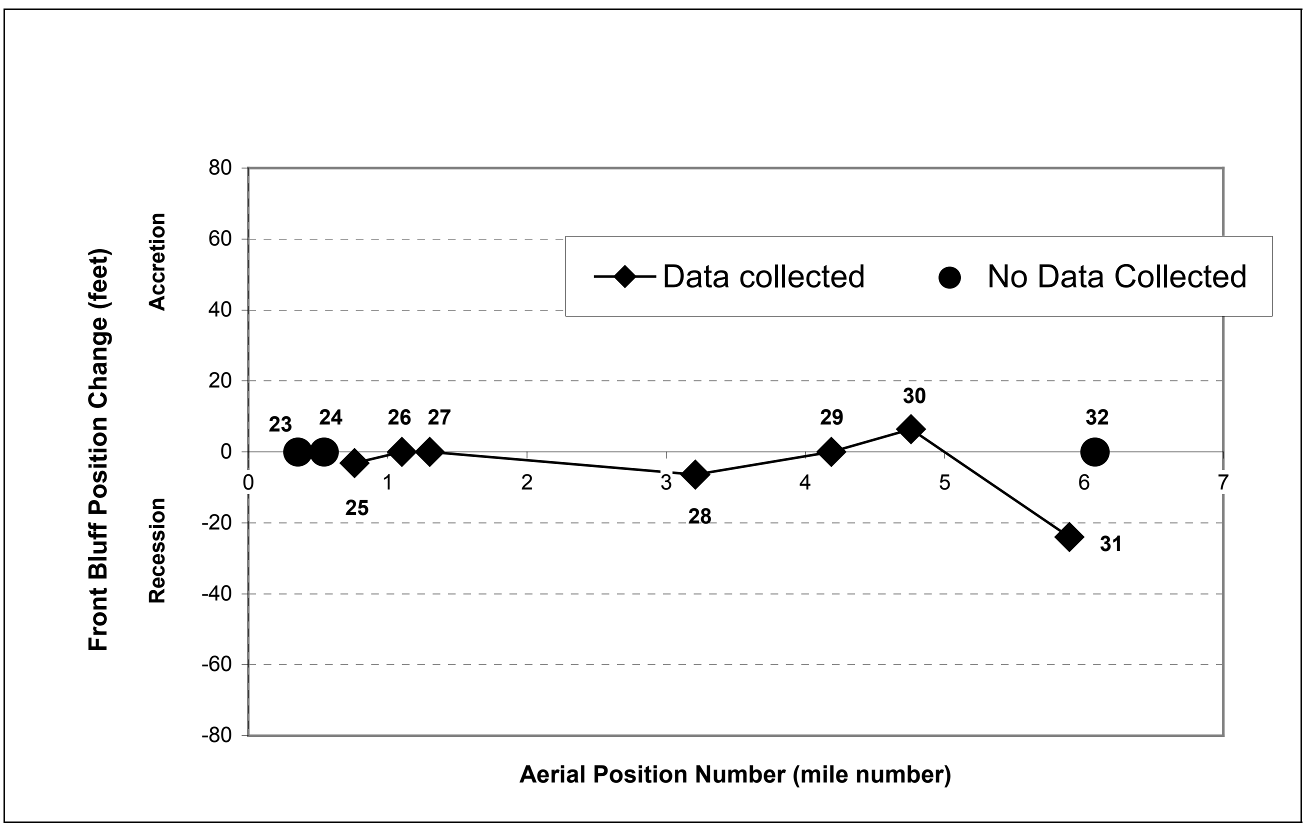


Figure 14: Cumulative Dune-Bluff Erosion Curve 1987 to 1995, Reach 4

AIRPHOTO	1938 - 1955		1955 - 1976		1976 - 1987		1987 - 1995			No. of
POSITION	Recession	Rate	Recession	Rate	Recession	Rate	Recession	Rate	Total	Years
NUMBER	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	
23	---	---	---	---	---	---	---	---	---	
24	---	---	---	---	---	---	---	---	---	
25	---	---	---	---	41.0	3.70	-3.2	-0.40	37.8	(19)
26	-65.1	-3.80	-161.4	-7.70	30.0	2.70	0.0	0.00	-196.5	(57)
27	-149.2	-8.80	-116.4	-5.50	-45.0	-4.10	0.0	0.00	-310.6	(57)
28	---	---	-27.3	-1.30	4.0	0.40	-6.4	-0.80	-29.7	(40)
29	---	---	-12.1	-0.60	30.0	2.70	0.0	0.00	17.9	(40)
30	-14.7	-0.90	0.7	0.03	51.0	4.60	6.4	0.80	43.4	(57)
31	43.1	2.50	7.1	0.30	---	---	-24.0	-3.00	26.2	(46)
32	---	---	---	---	---	---	0.0	0.00	0.0	
	Table 11: Cumulative Dune-Bluff Recession and Annual Recession Rates, Reach 4									

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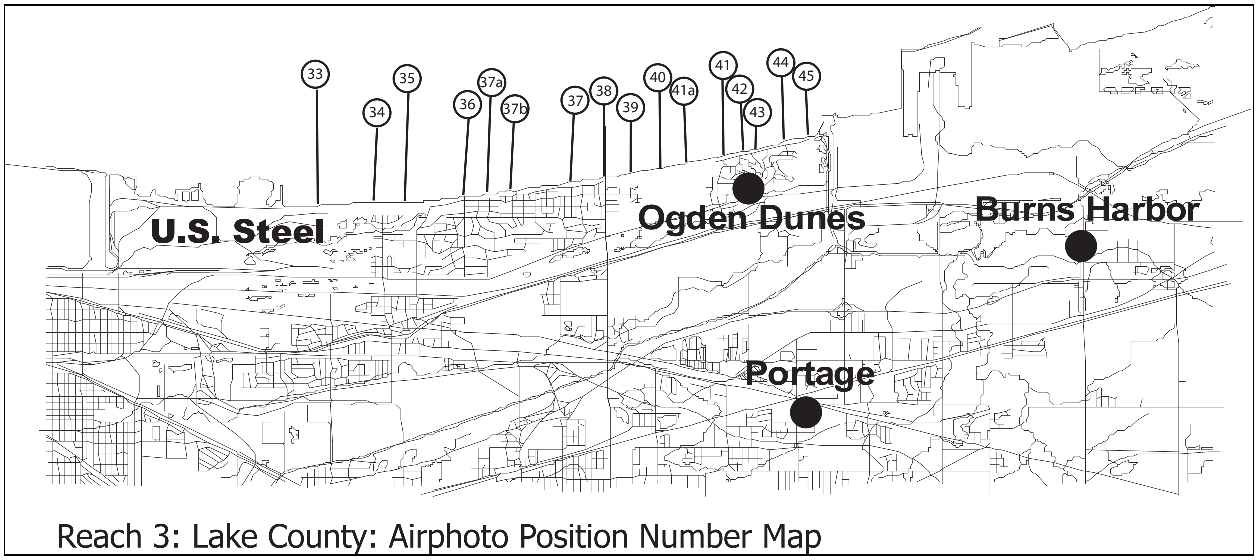
Coastal Stability, Reach 3

This reach evaluation presents detailed recession measurements for 19 locations from the Gary Harbor/U.S. Steel lakefill to Portage Burns Waterway as shown on Map 3. All of the locations are within the area designated as Reach 3 (Figure 2). Table 12 lists cumulative dune-bluff recession and annual recession rates for the 18-year period from 1969 to 1995. Figure 15 shows cumulative dune-bluff recession for the period 1987 to 1995.

This length of coastline is accretional in the western third and erosional in the eastern third (see Table 12). This indicates a definite migration of material toward the west. Dune-bluff accretion is observed from Marquette Park west to the U.S. Steel breakwater structure, from 1987 to 1995. This is a result of the overall westward movement of sediment being trapped on the east side of U.S. Steel lakefill breakwater. The central portion of Reach 3 (locations 37 to 40) is relatively stable over the study period with accretion being observed at two locations. Stability is to be expected in this transitional zone between accretional (western) and erosional (eastern) zones. Dune-bluff erosion rates from the west end of Ogden Dunes eastward to Portage Burns Waterway (locations 41 to 45) are severe and increase as the survey positions approach Portage Burns Waterway. This high erosion is the result of the combined effects of the Port of Indiana/Bethlehem Steel Industrial Complex being a “primary” sand trapping structure (total littoral barrier) and the breakwaters protecting this waterway acting as a “secondary” littoral barrier for sediment moving west. Recession was not determined at a few locations in Ogden Dunes where the dune-bluff was not distinguishable. The anomalous accretion shown at location 45 for the time period of 1984 to 1987 (see Table 13) is the result of a 127,000 cubic yards beach nourishment project placed immediately downdrift (west) from the new Portage Burns Waterway/Burns Small Boat Harbor breakwater in fall 1985. Detailed discussion of beach and offshore bathymetry as well as earlier erosion/deposition trends is given in Chapter 7 of the Indiana Dunes National Lakeshore Shoreline Situation Report (1986).



Map 3: Location Map, Reach 3

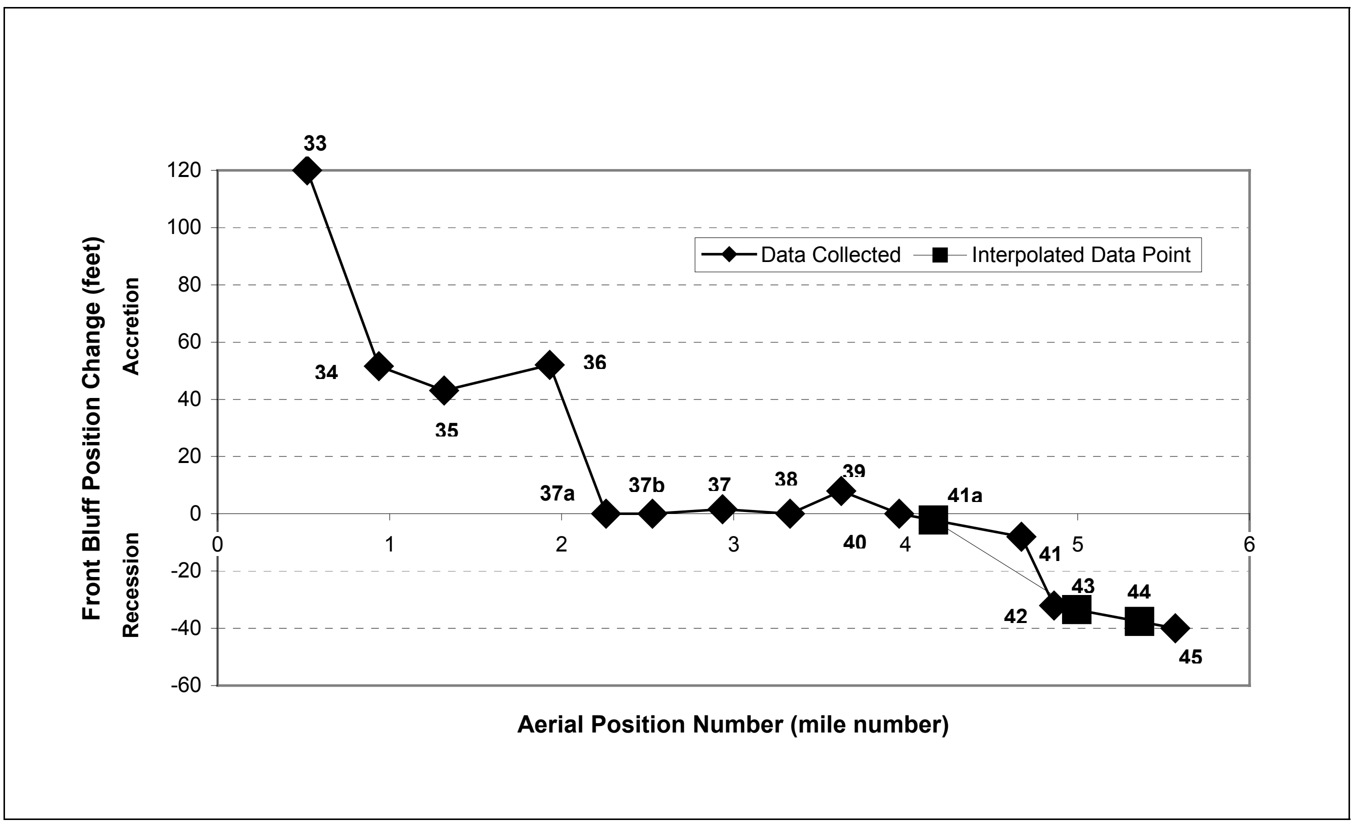


Figure 15: Cumulative Dune-Bluff Erosion Curve 1987 to 1995, Reach 3

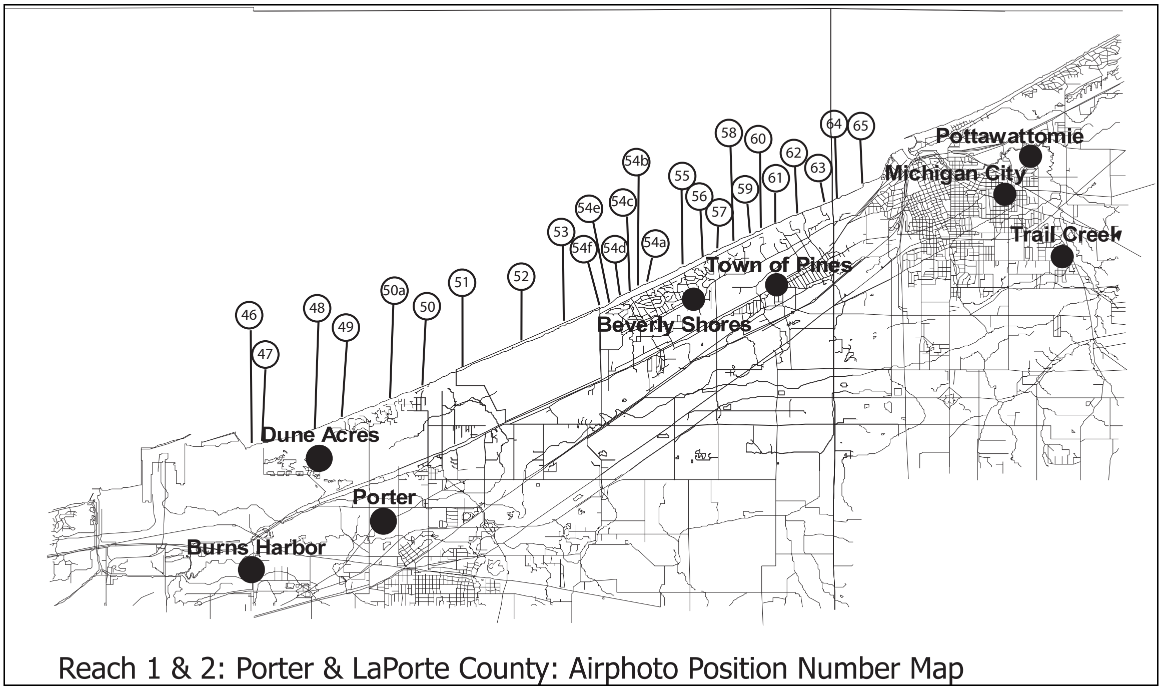
AIRPHOTO	ASSOCIATED	1969 - 1972		1972 - 1978		1978 - 1984		1984 - 1987		1987 - 1995			No. of
POSITION		Recession	Rate	Recession	Rate	Recession	Rate	Recession	Rate	Recession	Rate	Total	Years
NUMBER	SURVEY LINE OR ROAD	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	
33		---	---	---	---	26.0	4.33	-32.0	-10.67	120.0	15.00	114.0	(17)
34		---	---	---	---	0.9	0.15	4.0	1.33	51.6	6.45	56.5	(17)
35		---	---	---	---	38.1	6.35	6.4	2.13	43.1	5.39	87.6	(17)
36	Montgomery St.	---	---	---	---	12.7	2.12	22.8	7.60	52.0	6.50	87.5	(17)
37a		---	---	---	---	-34.4*	-5.73	34.0@	11.33	0.0	0.00	-0.4	(16)
37b		---	---	---	---	-15.2@	-2.53	20.0@	6.67	0.0	0.00	4.8	(16)
37		---	---	---	---	1.1	0.18	-9.6	-3.20	1.6	0.20	-6.9	(17)
38	County Line Rd.	---	---	---	---	-16.7	-2.78	3.2	1.07	0.0	0.00	-13.5	(17)
39		---	---	---	---	23.4	3.90	-22.4	-7.47	8.0	1.00	9.0	(17)
40		---	---	---	---	65.9	10.98	-19.2	-6.40	0.0	0.00	46.7	(17)
41a	GLCRL 1	---	---	---	---	7.2#	1.20	-3.2	-1.07	---	---	4.0	(16)
41		15.0	5.00	-57.5	-9.60	-1.4	-0.23	-41.6	-13.87	-8.0	-1.00	-93.5	(26)
42		13.6	4.50	-79.1	-13.20	0.4	0.07	-6.4	-2.13	-32.0	-4.00	-103.5	(26)
43		-37.4	-12.50	-62.6	-10.40	3.1	0.52	-25.6	-8.53	---	---	-122.5	(26)
44		-12.6	-4.20	-110.7	-18.50	-18.8	-3.13	-29.2	-9.73	---	---	-171.3	(26)
45		-45.9	-15.30	-120.4	-20.10	-48.0	-8.00	3.2	1.07	-40.0	-5.00	-251.1	(26)
	Table 12: Cumulative Dune-Bluff Recession and Annual Recession Rates, Reach 3												

* 1979-1986; @ 1986-1987; # 1979-1984

Coastal Stability, Reaches 1 and 2

This section presents detailed recession measurements for 34 locations from the Port of Indiana to Michigan City Harbor as shown in Map 4. All of the locations are within the areas designated as Reaches 1 and 2, which comprise a single littoral cell on the Indiana shoreline (Figure 2). Table 13 lists cumulative dune-bluff recession and annual recession rates for the 26 year period 1969 to 1995. Figure 16 shows cumulative dune-bluff recession for the period 1987 to 1995.

In summary, this length of coastline shows significant recession throughout a majority of the survey positions. Substantial accretion was found on the east (updrift) side of the Port of Indiana/Bethlehem Steel Industrial Complex in the extreme western end of Reach 2. This sand accumulation continues eastward about 1 mile (locations 46 to 48). This accretion was found to increase dramatically as the breakwater complex is approached. Historical dune-bluff recession rates from the 1988 report are variable in the eastern section of Reach 2 (approaching the west end of Beverly Shores) with some sections of coast having high recession and some low. This remained to be true for the 1998 investigation with an additional trend being observed. Zones of accretion alternate with zones of erosion. This trend was observed well into Reach 1. Construction of a 13,000-foot long rock revetment structure in front of Beverly Shores in 1975 greatly reduced recession rates between locations 54b and 59 through 1987. Unfortunately, failure and repeated repairs of portions of this shoreline armor has resulted in increased recession, especially in the western portion of Beverly Shores (locations 54b to 55) where excessive erosion was recorded. Dune-bluff recession and erosion in the extreme eastern end of Reach 1 at Mt. Baldy (locations 62 to 65) is historically the highest on the Indiana coastline (8 to 10 feet per year). Although the erosion from 1987 to 1995 was not as high as previously reported values, erosion still continues and extends westward to the eastern end of the Beverly Shores' rock revetment (location 60). Several locations where the dune-bluff was not distinct were identified. A federally authorized beach nourishment project for this section of shoreline is urgently needed. This urgency is predicated on the need to protect this impacted length of shore and most importantly to replenish sediment removed from the littoral transport system by the updrift Michigan City Harbor structures. Detailed discussion of beach and offshore bathymetry as well as earlier erosion/deposition trends is given in Chapters 5 and 6 of the Indiana Dunes National Lakeshore Shoreline Situation Report (1986).



Map 4: Location Map, Reach 1 & 2

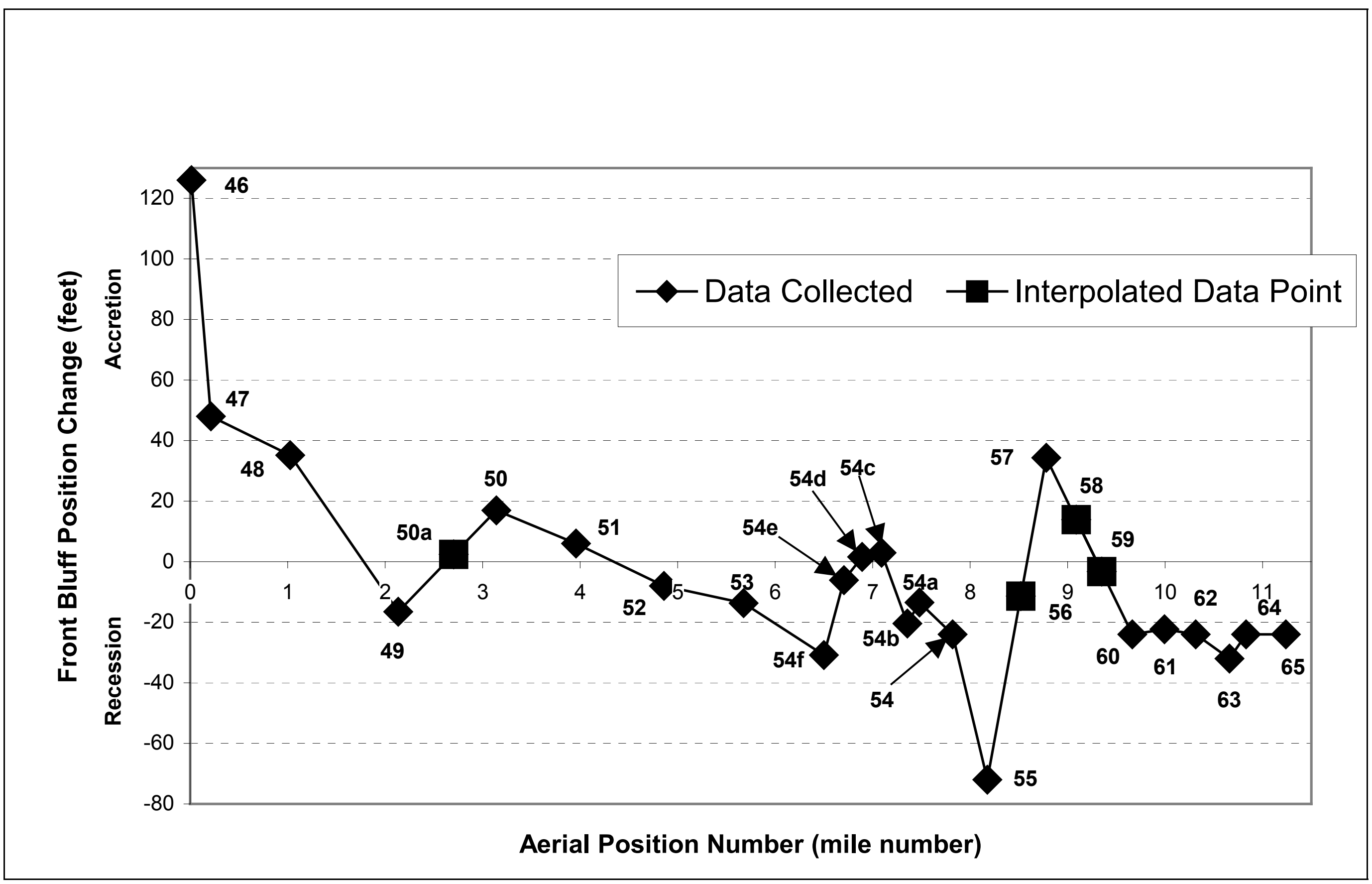


Figure 16: Cumulative Dune-Bluff Erosion Curve 1987 to 1995, Reach 1 & 2

		1969-1973		1973-1984		1984-1987		1987-1995			
AIR PHOTO POSITION NUMBER	SURVEY LINE OR ROAD	Recession (feet)	Rate (ft/yr)	Recession (feet)	Rate (ft/yr)	Recession (feet)	Rate (ft/yr)	Recession (feet)	(ft/yr)	Total Recession (feet)	Number of Years
46	CERC 7	4.4	1.10	-13.2	-1.20	-5.4	-1.80	126.0	15.75	111.8	(26)
47	CERC 8	0.0	0.00	45.0	4.09	-8.0	-2.67	48.0	6.00	85.0	(26)
48	CERC 9	-30.2	-7.55	17.2	1.56	-5.2	-1.73	35.2	4.40	17.0	(26)
49	CERC 10	-81.8	-20.45	9.6	0.87	6.2	2.07	-16.5	-2.06	-82.5	(26)
50a		---	---	---	---	-48.0	-16.00	---	---	-48.0	(11)
50	CERC 11	9.1	2.28	-4.2	-0.38	3.2	1.07	17.0	2.13	25.1	(26)
51	CERC 12	-31.7	-7.93	169.4	15.40	-108.8	-36.27	6.0	0.75	34.9	(26)
52	CERC 13	-65.7	-16.43	113.9	10.35	-118.4	-39.47	-8.0	-1.00	-78.2	(26)
53	CERC 14	-43.8	-10.95	51.4	4.67	-34.4	-11.47	-13.7	-1.71	-40.5	(26)
54f	15-1 Kemil Rd	---	---	---	---	-16.0	-5.33	-30.8	-3.85	-46.8	(11)
54e	Windsor Pl	---	---	---	---	-28.8	-9.60	-6.1	-0.76	-34.9	(11)
54d	Dunbar Ave.	---	---	---	---	-31.0	-10.33	1.6	0.20	-29.4	(11)
54c	Derby Ave.	---	---	---	---	-48.0	-16.00	2.9	0.36	-45.1	(11)
54b		---	---	---	---	-3.2	-1.07	-20.4	-2.55	-23.6	(11)
54a	b/n Broadway & Greatwater	---	---	---	---	-6.4	-2.13	-13.5	-1.69	-19.9	(11)
54	16-1 Shore Ave.	-19.9	-4.98	-2.2	-0.20	-54.4	-18.13	-24.0	-3.00	-100.5	(26)
55	16-A (SR-4)	-72.6	-18.15	-5.8	-0.53	-24.0	-8.00	-72.0	-9.00	-174.4	(26)

		1969-1973		1973-1984		1984-1987		1987-1995			
AIR PHOTO POSITION NUMBER	SURVEY LINE OR ROAD	Recession (feet)	Rate (ft/yr)	Recession (feet)	Rate (ft/yr)	Recession (feet)	Rate (ft/yr)	Recession (feet)	(ft/yr)	Total Recession (feet)	Number of Years
56	16-B Beach Ave.	-38.0	-9.50	-13.3	-1.21	-12.8	-4.27	---	---	-64.1	(26)
57	17-1 (SR-4)	-89.3	-22.33	-4.6	-0.42	3.2	1.07	34.3	4.29	-56.4	(26)
58	17-A	-19.1*	-4.78	-8.7@	-0.79	6.4	2.13	---	---	-21.4	(26)
59	17-B (SR-5)	---	---	-4.6	-0.42	19.2	6.40	---	---	14.6	(26)
60	18-1 (SR-6)	-42.6	-10.65	-3.2	-0.29	-57.6	-19.20	-24.0	-3.00	-127.4	(26)

Table 13: Cumulative Dune-Bluff Recession and Annual Recession Rates, Reaches 1 and 2
* 1964-1972; @ 1972-1984
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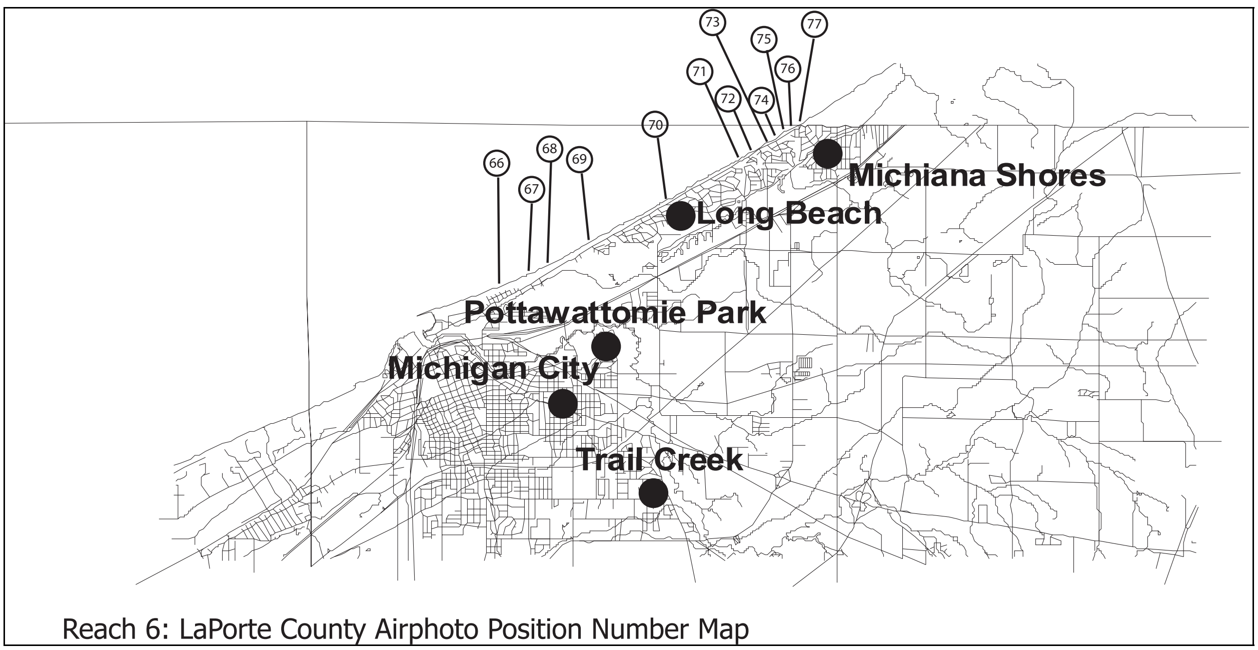
Coastal Stability, CZM (Reach 6)

This reach evaluation presents detailed recession measurements for 12 locations from Michigan City Harbor to the Indiana-Michigan state line as shown in Map 5. Table 14 lists cumulative dune-bluff recession and annual recession rates for the 17-year period 1978 to 1995. Figure 17 shows cumulative dune-bluff recession for the period 1987 to 1995.

In summary, this length of coastline has accretion at the western end at the Michigan City lighthouse jetty (location 66 to 69); is fairly well armored in the central section though the town of Long Beach (locations 69 to 74); and is recessional at the eastern end to the Michigan state line (locations 75-77). The dune-bluff buildup that was identified east of Washington Park (locations 66 to 68) in 1987 continued over the eight years of this investigation (Table 14). This accretion occurs in the region of deposition caused by the sand trapping effect of the Michigan City Harbor structures. Owing to the extensive seawall and revetment structures, the sediment trapping at Michigan City Harbor and the lack of a major sediment barrier to the east, almost this entire coastline has relatively low recession rates. Only the extreme eastern end of this reach shows significant erosion, Figure 17 (locations 76 and 77). In the late 1980s, a rock revetment structure and a short segment of sheet-steel wall was constructed to protect the lakeshore road and to stabilize this length of coastline extending from the eastern end of Long Beach to the Michigan state line. Detailed discussion of beach and offshore bathymetry, as well as earlier erosion/deposition, trends is presented in Shoreline Situation Report for LaPorte County, Indiana (1981).



Map 5: Location Map, CZM (Reach 6)

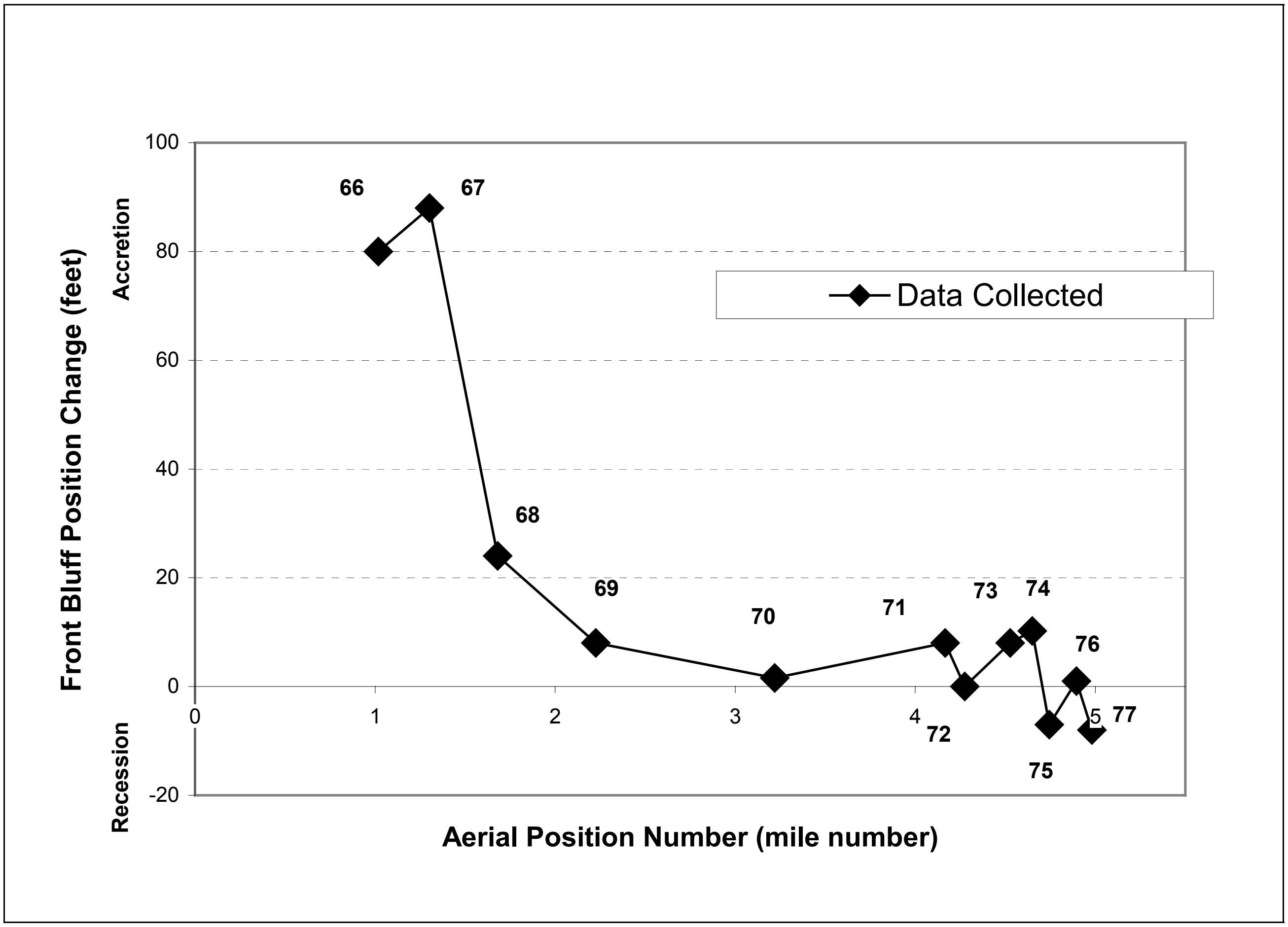


Figure 17: Cumulative Dune-Bluff Erosion Curve 1987 to 1995, CZM (Reach 6)

AIRPHOTO POSITION NUMBER	APPROXIMATE SURVEY LINE OR ROAD	1969 - 1973 Recession (feet)	Rate (ft/yr)	1973 - 1978 Recession (feet)	Rate (ft/yr)	1978 - 1980 Recession (feet)	Rate (ft/yr)	1980 - 1987 Recession (feet)	Rate (ft/yr)	1987 - 1995 Recession (feet)	Rate (ft/yr)	Total (feet)	No. of Years
66	Georgia Ave	---	---	12.6	2.52	-37.8	-18.90	80.8	11.54	80.0	10.00	135.6	(22)
67	Carolina	-54.7	-13.68	19.2	3.84	-33.3	-16.65	102.8	14.69	88.0	11.00	122.0	(26)
68	Turner Ave.	-48.3	-12.08	-8.0	-1.60	-17.0	-8.50	75.2	10.74	24.0	3.00	25.9	(26)
69	SR-23	---	---	---	---	3.0	1.50	6.0	0.86	8.0	1.00	17.0	(17)
70	R-24 Hazeltine Dr. (SR-25)	---	---	---	---	-21.3	-10.65	4.3	0.61	1.6	0.20	-15.4	(17)
71	near Morre Rd.	---	---	---	---	-0.5	-0.25	8.2	1.17	8.0	1.00	15.7	(17)
72	Duneland Rd.	---	---	---	---	7.4	3.70	-7.6	-1.09	0.0	0.00	-0.2	(17)

AIRPHOTO	APPROXIMATE	1969 - 1973		1973 - 1978		1978 - 1980		1980 - 1987		1987 - 1995			No. of
POSITION		Recession	Rate	Recession	Rate	Recession	Rate	Recession	Rate	Recession	Rate	Total	Years
NUMBER	SURVEY LINE OR ROAD	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	(ft/yr)	(feet)	
73	Iroquois Tr.	---	---	---	---	7.4	3.70	16.4	2.34	8.0	1.00	31.8	(17)
74	Arrowhead Trail	---	---	---	---	-1.8	-0.90	0.8	0.11	10.2	1.28	9.2	(17)
75	b/n Michinda & Arrowhead Tr.	---	---	---	---	-2.7	-1.35	1.2	0.17	-7.0	-0.88	-8.5	(17)
76	Michinda Tr.	---	---	---	---	-11.9	-5.95	-22.4	-3.20	1.0	0.13	-33.3	(17)
77	near Michiana SR-26(state line)	---	---	---	---	-20.1	-10.05	-46.4	-6.63	-8.0	-1.00	-74.5	(17)
	Table 14: Cumulative Dune-Bluff Recession and Annual Recession Rates, CZM (Reach 6)												